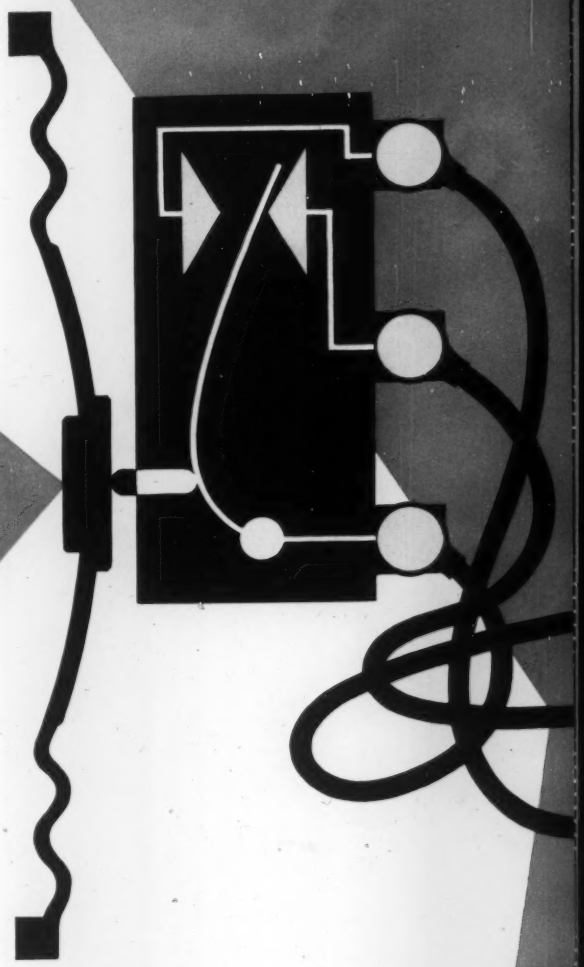
AUGUST 22, 1957

MACHINE DESIGN

A PENTON PUBLICATION — BIWEEKLY



Pressure Switches

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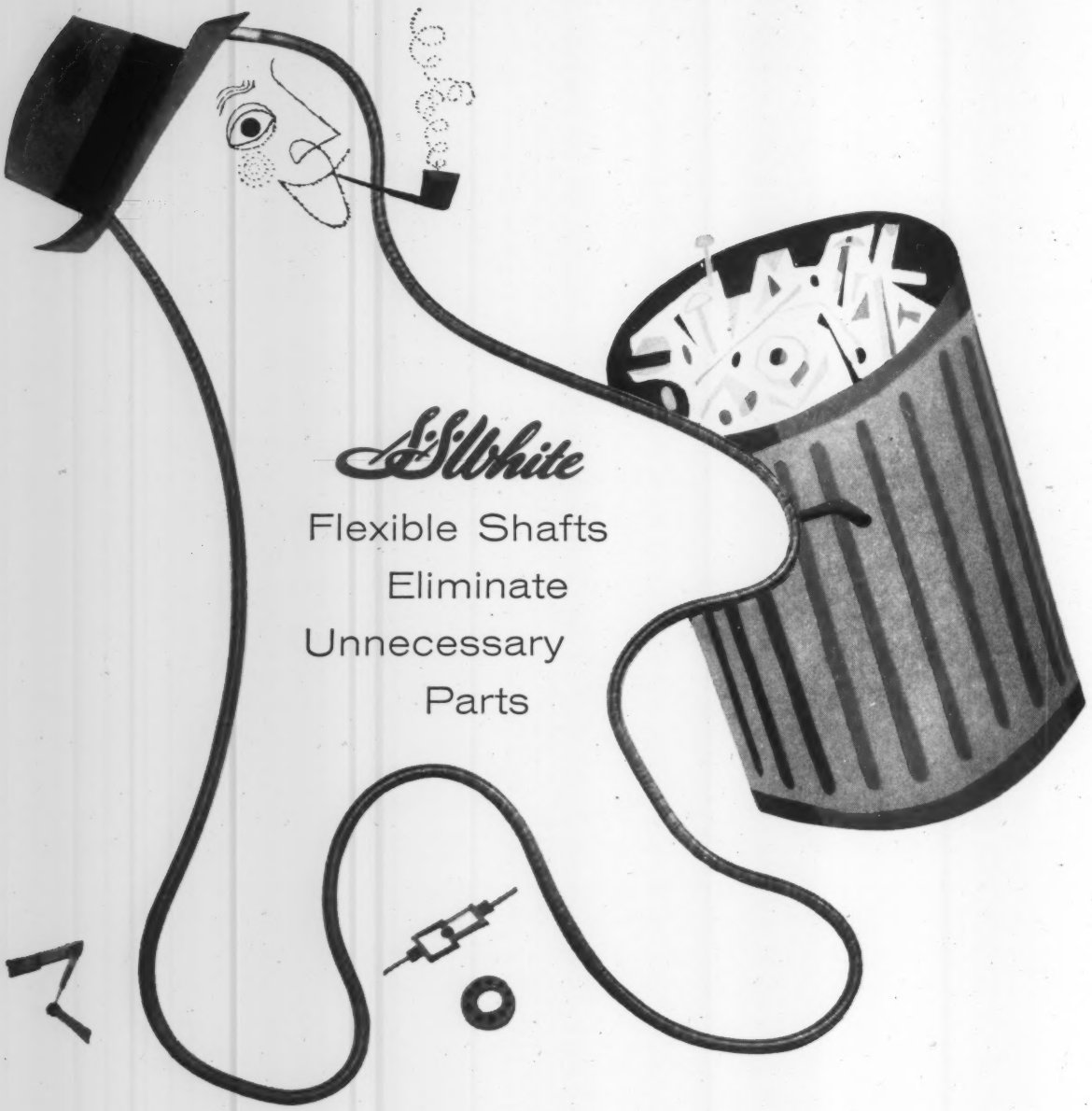
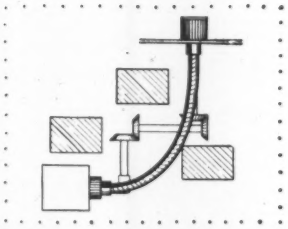


One manufacturer used flexible shafts to replace 35 parts in a Hydraulic Power System . . . cut costs by 90%. Four flexible shafts replaced a 35-part remote-control system . . . simplified design . . . made assembly easier . . . eliminated alignment problems . . . improved performance!

This is only one of hundreds of remote control and power drive problems these quality flexible shafts are solving in every industry today. Can S.S. White flexible shafts help improve *your* product? Perhaps make it lighter in weight . . . cut production costs . . . eliminate unnecessary parts?

If you'd like to know more about flexible shafts, the advice of our engineers costs you nothing. Just write to



S. S. White Industrial Division, Dept. 4, 10 East 40th Street, New York 16, N. Y.
Western Office: 1839 West Pico Blvd., Los Angeles 6, Calif.

S.S.White
FIRST NAME
IN FLEXIBLE SHAFTS

Useful data on how to select and apply flexible shafts! Write for Bulletin 5601.

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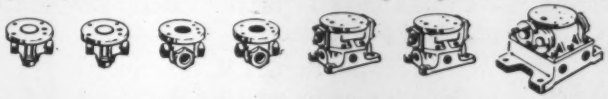
Ross Skyline

Silvermodel JIC Spool Solenoid

Any Skyline Head Attaches to Any Skyline Valve Body



Interchangeable! 25 Million Cycles in Tests!

Now the JIC spool solenoid valves join the Ross Skyline. Now six actuating heads and seven in-line and base mounted bodies—all completely interchangeable—give you any valve you want in this series designed especially to last millions more cycles than ordinary valves. But, these quality valves come to you at *sensible* prices! For instance, the ⅜" Silvermodel base mounted, 4-way is only $62.50 complete, and complies with all JIC requirements. Write for bulletin 315.

Ross OPERATING VALVE COMPANY

109 EAST GOLDEN GATE AVENUE • DETROIT 3, MICHIGAN

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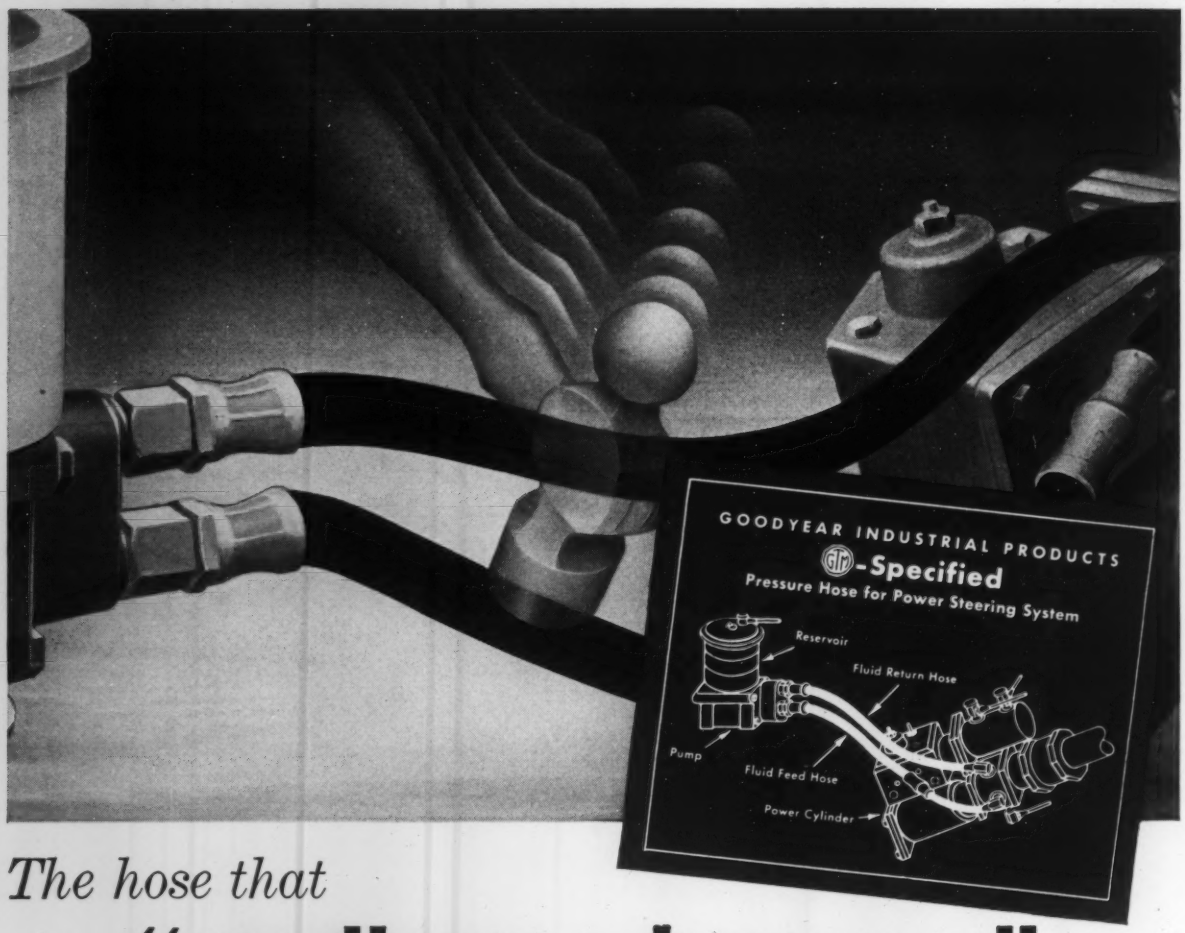

The hose that

"swallows a hammer"

–to make power steering possible

MANY were the headaches in the development of power steering. One big problem was to eliminate the excessive vibration and noise from the first trial units. Rapid changes of high pressures were the cause. Steel pressure accumulators were a solution, but they were too high in cost and maintenance.

Then, someone thought of hose. They tried common water hose. Over a hundred feet was needed–far too much to put under an automobile. Shorter lengths of every possible type were tried without success. Finally, the G.T.M.–Goodyear Technical Man–was called in.

His answer was a special hose that withstood the over 600 pounds' pressure; that expanded between certain pressures to absorb the "Hammer"; that resisted engine-heat, oil, grease and hydraulic fluid – all in a mere *18 inches'* length. The result was practical power steering. What can he do for you?

You can consult the G.T.M. through your Goodyear Distributor or by writing Goodyear, Industrial Products Division, Akron 16, Ohio.

YOUR GOODYEAR DISTRIBUTOR *can quickly supply you with Hose, Flat Belts, V-Belts, Packing or Rolls. Look for him in the yellow pages of your Telephone Directory under "Rubber Products" or "Rubber Goods."*

GOODYEAR

THE GREATEST NAME IN RUBBER

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August 22, 1957 Volume 29—No. 17

THE PROFESSIONAL JOURNAL FOR ENGINEERS AND DESIGNERS

MACHINE DESIGN

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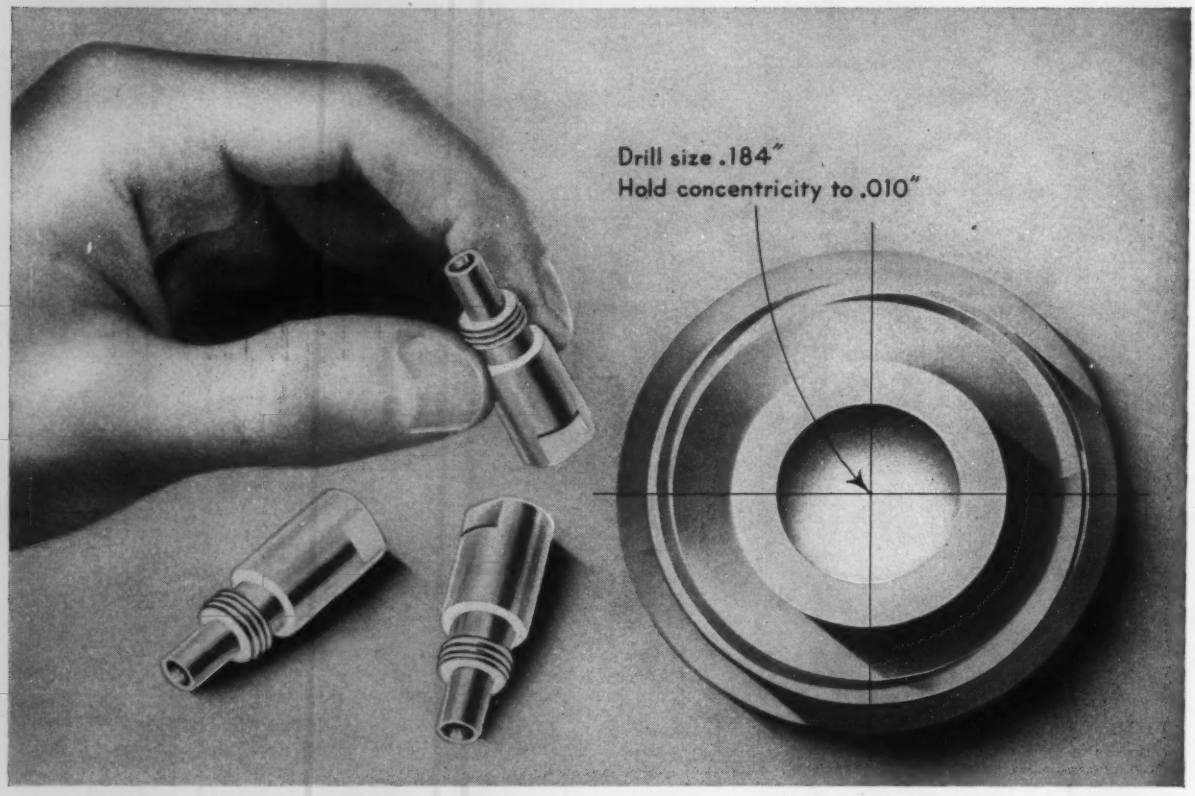
How Anaconda can help you get the exact Rod to fit the job



THE broad line of Anaconda free-cutting copper and copper-alloy rods gives you widest latitude in selecting from warehouse stock the precise rod for most screw machine jobs. But every once in a while there are special requirements.

One company's problem: The M. J. Grass Screw Machine Products Co., Buffalo, N. Y., machines a part for a gas-burner base from ½" round free-cutting brass rod. Specifications call for a hole $1\frac{1}{16}$" deep by .184" in diameter—with concentricity held to .010".

With standard free-cutting brass rod the drill had a tendency to wander, running the concentricity off as much as .024". To correct this, The American Brass Company provided rod stock with a minor variation in fabrication for deep drilling. This free-cutting brass rod has a slightly harder core, which minimizes the tendency of the drill to run off center at the high drilling speeds used. Now M. J. Grass holds the concentricity to .008" or under. With regular free-cutting brass, rejects ran as high as 15%. With the deep-drilling rod, there are no rejects.

Your requirements: Anaconda Rods are consistently uniform in composition, temper, and free-cutting characteristics. Consequently, they make possible easy duplication of cutting speeds and feeds known to be satisfactory from previous job records.

When you need special physical characteristics, such as a harder core for deep drilling or additional ductility to permit spinning or cold forming after machining, either the temper, the alloy, or both can be adjusted to meet your requirements.

Free technical service: It is the function of the Technical Department of The American Brass Company to assist metal users in the solution of special problems. This service is at your disposal without charge.

Comprehensive data on composition and machinability of standard Anaconda Alloys, standard specifications, weights, and dimensions of standard rods is available in Publication B-3. For this booklet — for special technical assistance — write: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont. 5770

ANACONDA® RODS FOR SCREW MACHINE PRODUCTS

MADE BY THE AMERICAN BRASS COMPANY

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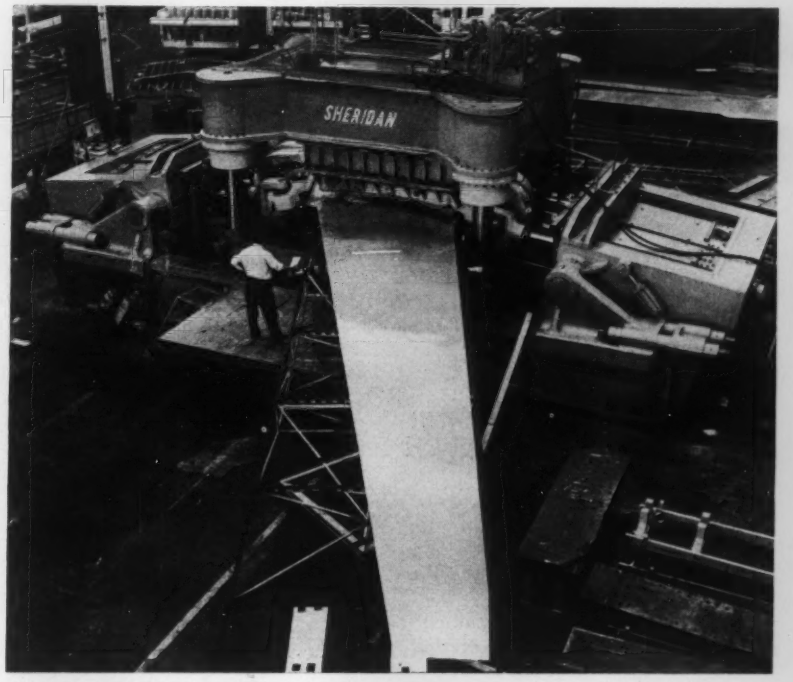
Engineering News Roundup



Airfoil shape is formed in the wings of DC-8 jetliners by this four-directional stretch press at Douglas Aircraft. Workpiece is a 1200-lb sheet of aluminum, 50 ft long, tapered in thickness from 0.230-in. to 0.135-in.

Four-Directional Stretch Press Forms Stronger Wing Sections

Largest Machine of Its Type Uses Exceptionally Long Stock

LONG BEACH, CALIF.—The largest four-directional stretch press in the world is being used by Douglas Aircraft Co. to form airfoil sections from 10 by 50-ft aluminum plate. The big Sheridan press was designed specifically to contour DC-8 jetliner airfoils, assuring greater wing strength for the aircraft.

"Skins" weighing 1200 lb, much thicker than those used on current aircraft, are delivered to the press tapered longitudinally from 0.230 to 0.135-in. After rough trimming, the plate is moved to a power brake where a dihedral angle is formed. The four-way stretch is then accomplished by centering the dihedral bend over a form die ram and engaging the stretch press jaws to the fore and aft sides of the skin.

The ram rises under 450-ton pressure, stretching the skin longitudinally while four jaws each exert a 150-ton pull to stretch the skin chordwise. During this process a holding fixture extends well beyond the press to support the outboard part of the 50-ft skin.

A template is used to guide a second rough trimming that brings the part to within 4 in. of its final dimensions before introduction to the aging oven.

Army Adopts Metric Standard For Weapons, Related Items

Arms, Existing and Building To Be Modified by Jan. 1, 1966

WASHINGTON, D.C.—Metric units are now standard for the measurement and expression of linear distances on all weapons and related equipment of the U.S. Army. Equipment currently in existence and under development will be converted to metric linear units before January 1, 1966.

The new metric policy is announced in Army Regulation No. 700-75. Objectives of the policy, according to the regulation, are "to establish a common unit of measurement in connection with the operation of all United States Army weapons, to facilitate standardization within NATO, to permit better and more extensive use of allied and captured enemy materiel, and to simplify firing procedures for indirect firing weapons."

The policy is to be put into effect as follows:

1. "All existing survey and fire direction equipment for United States Army weapons, to include firing tables and equipment for gathering fire direction data, will be converted with the least practicable delay in order to measure ranges and heights in meters."

2. "Equipment will not be modified if it is to be replaced by items currently in development which are scheduled to enter the supply system prior to 1 January 1966, or if it otherwise will be phased out of the logistic system prior to 1 January 1966."

3. "Existing known distance ranges will be redesignated to the nearest ten meters, *for example:* 180, 270, or 460. New ranges will be constructed in round hundreds of meters."

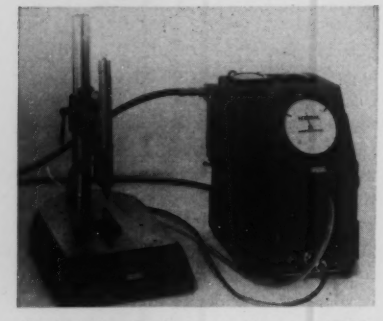
4. "All United States Army weapons and related equipment, to include sighting and fire control equip-

ment, firing tables, charts, range finders, radars, training aids, and other ancillary equipment now in development and developed in the future, will be designed to employ the meter as the unit of linear measurement."

5. "Units of measure for expressing meteorological data for United States Army weapons systems are not changed by these regulations. Wind speeds will continue to be expressed in miles per hour and barometric pressures in millibars or inches of mercury."

Pressureless Measuring Gage Checks Small, Delicate Parts

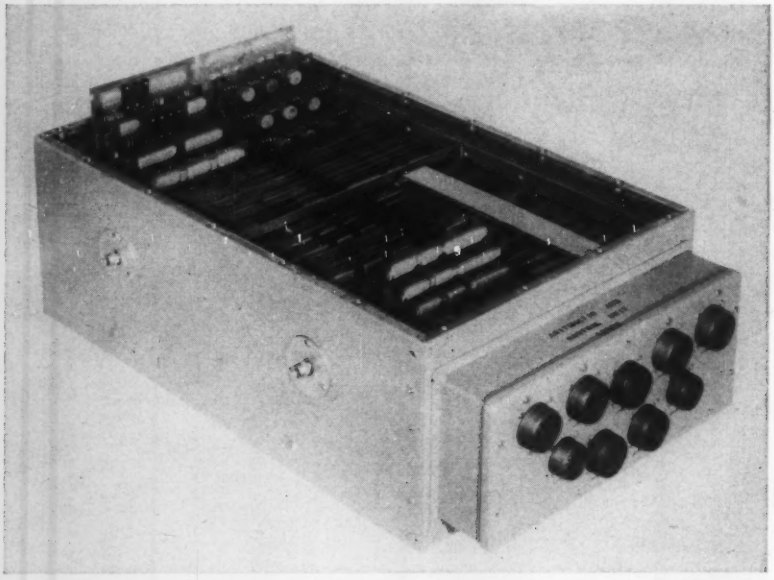
PROVIDENCE, R.I.—A pressureless gage for measuring delicate parts such as light springs and vacuum tube grids, has been developed by Federal Products Corp. The air-



electronic device exerts negligible 0.005-gram pressure.

Sensitive gaging contact is raised and lowered by special wire that has rapid response to heat and is made to fluctuate in length by being alternately heated and cooled. To begin the gaging cycle, the wire is heated, causing it to lengthen and move the contact toward workpiece. As soon as contact touches workpiece, a circuit is established that removes voltage across wire, allowing the wire to cool and contract.

Gaging mechanism consists of the gage head connected by a frictionless motion transfer unit to the sensitive contact and by plastic hose to an air gage. Movement of the contact causes a target face in gage head to move against an air jet so that movement can be seen on dial.



FILE-LIKE ARRANGEMENT of small printed circuit cards comprises the basic unit of Philco's Transac C-1100 airborne computer. More than 3000 transistors are included in circuitry that performs computational problems for flight control. The exceptionally small computer occupies less than four cu ft of space; requires less power to operate than a 25 w light bulb.

Thermal-Imaging Camera Pictures Temperature Change

Steel Plant Equipment Studied From Photos of Heat Radiation

FAIRLESS HILL, PA.—A new type of camera called an "evaporograph" is being used for the first time in the steel industry to observe blast furnaces, coke ovens, open-hearths and other steel-making facilities at U.S. Steel's Fairless Works.

Test observations and color photographs made with the instrument throughout the mill area have shown that temperature differences on the exterior surface of high-temperature operating units make possible the study of interior wall conditions. For this reason the evaporograph is said to answer a definite need of the operation and maintenance departments in steel mills. It shows promise also as a detector of hot-spots or worn areas in machinery, steam lines and other equipment where temperature is a measure of interior conditions.

Developed by Baird-Atomic Inc. as a direct thermal-imaging device, the new instrument functions as efficiently in absolute darkness as in daylight, requiring no source of external illumination. Instead, it forms a colored, two-dimensional image by utilizing the long-wavelength, infrared radiation emitted from the object or area being photographed. Sensitivity of the device is such that differences of 1-degree C can be detected in the target temperatures. It will function so long as the target temperature is above absolute zero and there is a temperature difference existent in the field of view. Objects at distance of three miles or more will register accurately.

Heart of the new instrument is the evaporograph cell, a vacuum-en-

Front Cover

Pressure-sensitive switches are handy gadgets that can sense high or low fluid pressures and actuate a warning device or control an electrical circuit. George Farnsworth's cover shows a diaphragm type to epitomize Bill Wallace's article on page 106.

. . . Fluid Power news

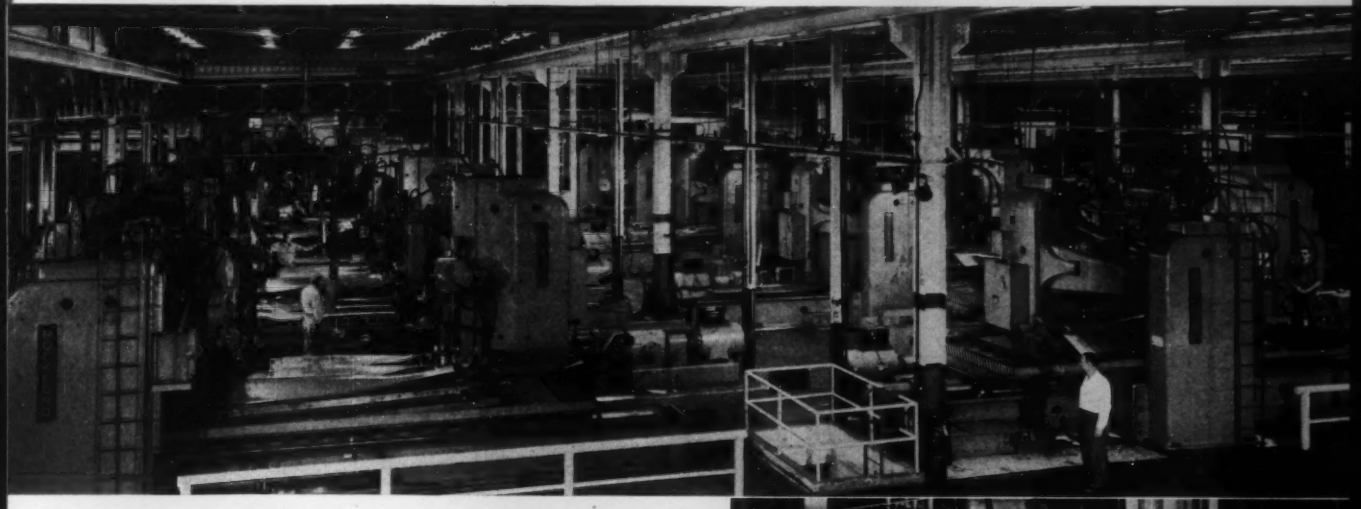
REPORT NO. 11,600 AID TO MACHINE DESIGN PROGRESS

. From Oilgear Application-Engineering Files

HOW OILGEAR ENGINEERING TEAMWORK AIDS MACHINE DESIGN PROGRESS

CUSTOMER: Rockford Machine Tool Company

DATA: Application of Fluid Power system to planers that mass-duplicate the airfoil on new, solid, forged steel propeller blades. Six years has been spent on the development and manufacturing methods to produce this new blade. Planers to be equipped with tracer attachments to machine blades from master templates. Desired profile is completely machined to proper thickness . . . maintaining accurate airfoil on both sides of blade. Requirements: extreme accuracy; flexibility of control; elimination of shock, vibration and gear marks on work; independent, fast cutting and return speeds to keep costs to a minimum.



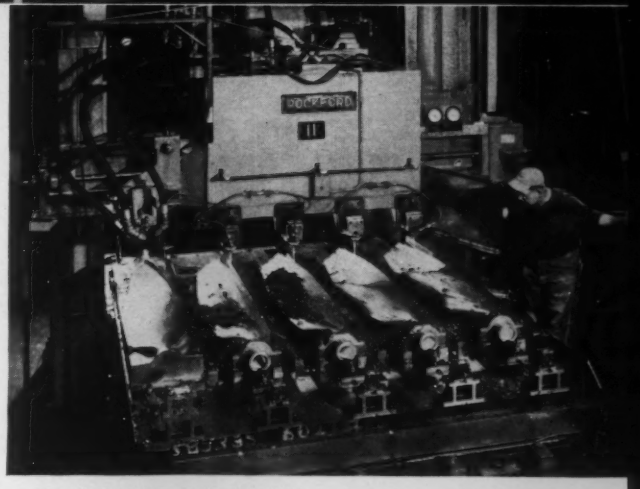
SOLUTION: Shown above are 20 Oilgear-equipped, Rockford Hy-Draulic planers machining aircraft propeller blades. Closeup (right) shows how Rockford's hydraulically operated "Kopy-Kats" can mass-duplicate four of these new-type, steel blades simultaneously from master templates. Rockford Machine Tool says of this set up, "The inherent advantages of hydraulic drive and control make this gigantic installation an extremely powerful production unit. Hydraulic drive is a natural for reciprocating machine tools. It's being proven daily in the world's finest machine shops." This is but *one* example of the ever increasing application of Oilgear-equipped machine tools. Rockford, and other designers and builders of tools for industry, have discovered that Oilgear *Application-Engineering* means cooperation and teamwork in supplying new production requirements . . . that Oilgear is more than just an "off-the-shelf" source of supply . . . that Oilgear is a Fluid Power design and engineering service based on over 35 years of pioneering and knowledge in precision, "Any-Speed" control, and efficient linear and rotary power systems. Because of this cooperative teamwork in solving problems—coupled with progressively engineered, trouble-free, dependable, Fluid Power control and drive systems—manufacturers have come to trust and depend upon Oilgear . . . the name that protects and enhances "OEM's" reputation, and assures satisfied users.

For practical solutions to YOUR *linear or rotary drive and control problems, call the factory-trained Oilgear application-engineer in your vicinity. Or write, stating your specific requirements, directly to . . .*

THE OILGEAR COMPANY

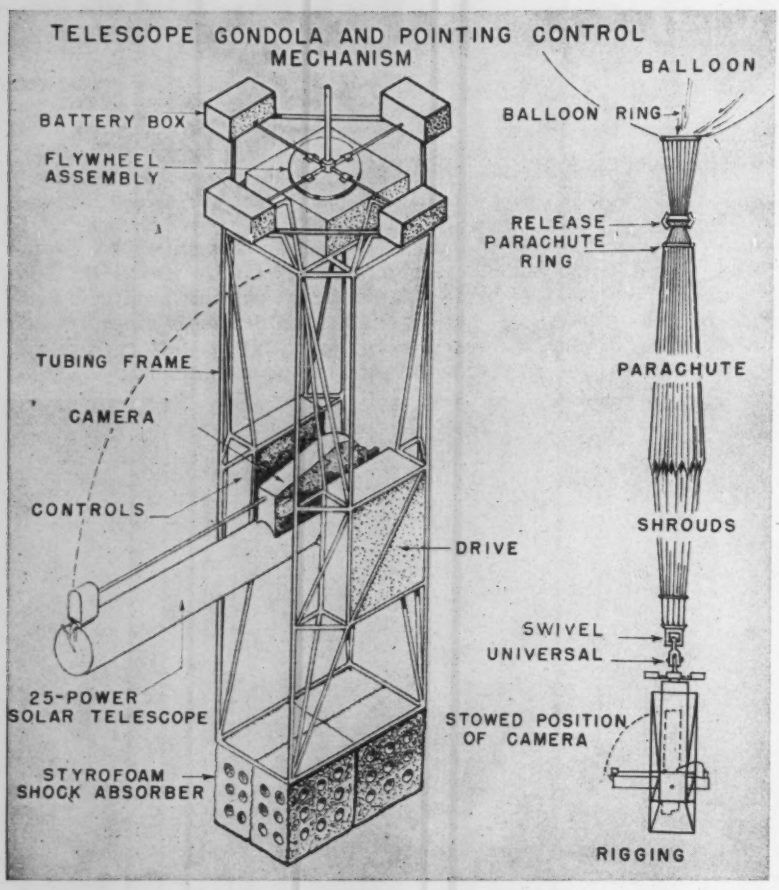
Application-Engineered Fluid Power Systems

1568 WEST PIERCE STREET • MILWAUKEE 4, WISCONSIN



Rockford Machine Tool Company has used thousands of Oilgear Fluid Power Systems on planers and slotters since 1928, because of: 1: No costly high inertia, reversible, electric motors; complicated control systems, and reduced power consumption and vibration. 2: No racks, screws, gear trains. 3: Infinite speeds from 10 to 300 fpm, with 3 cutting force ranges-independent maximum return speed. 4: Shock-free, instant reversals for efficient short or long stroke cutting. 5: New, complete flexibility in operational control.

Please direct inquiries to advertiser, mentioning MACHINE DESIGN



AIMED AT THE SUN, this balloon-mounted camera will take better astronomical pictures during IGY than rocket-mounted cameras could provide. When balloon levels off at high altitude, normal pendulum swing of only 1/10-degree provides relatively stable instrument platform. Electric eyes automatically point telescope by activating magnetic clutches on motor-driven flywheel. Telescope is constructed of Invar metal to resist warping under temperature change. The 25-power telescope, focused by a 12-in. reflecting lens, is expected to produce clearer pictures than the 200-in. telescope at Mt. Palomar. Office of Naval Research is project sponsor. Balloon is built by General Mills; camera aiming device at University of Colorado.

closed membrane on which a thin film of oil condenses. If the image of an object is focused on a blackened side of the membrane, different portions of the membrane will be at different temperatures because of variations in the infrared radiations from the target. The oil will condense preferentially upon the cooler portions of the membrane. This variable condensation causes variation in the thickness of oil film which in turn changes the apparent color of each temperature-differential area of the membrane. Thus, the heat image focused on the membrane becomes visible and distinguishable through the different interference colors formed by the oil film. An oil slick on water exhibits the same colors.

The viewing optical system is equipped with a light source which illuminates the membrane uniformly and forms an image of the membrane on 35-mm photographic film and in an eyepiece for direct observation.

By employing a reference temperature in the field of view, the evaporograph can be used to calculate unknown temperatures.

Topics

Helicopter carrier, the first ship built especially for that purpose, is under construction for the French Navy. The 10,000-ton carrier will accommodate 12 turbojet-powered helicopters, which will be larger than any helicopters now in use.

• • •

Vacuum-packaged Plymouth reposes in a concrete vault beneath the Tulsa, Okla., courthouse lawn, preserved for posterity as an example of products of the "1957 machine era." The car is protected by rust-inhibiting crystals in the gasoline tank, crankcase and radiator; rust-preventive paper covering top, bottom, interior areas and engine; and finally, by a huge bag of laminated cotton fabric, polyethylene, aluminum foil and vinyl.

• • •

A fair shake: Testing machines built by Ford engineers inflict as much punishment on car bodies and frames in 20 hr as would occur in several years of driving on rough roads.

• • •

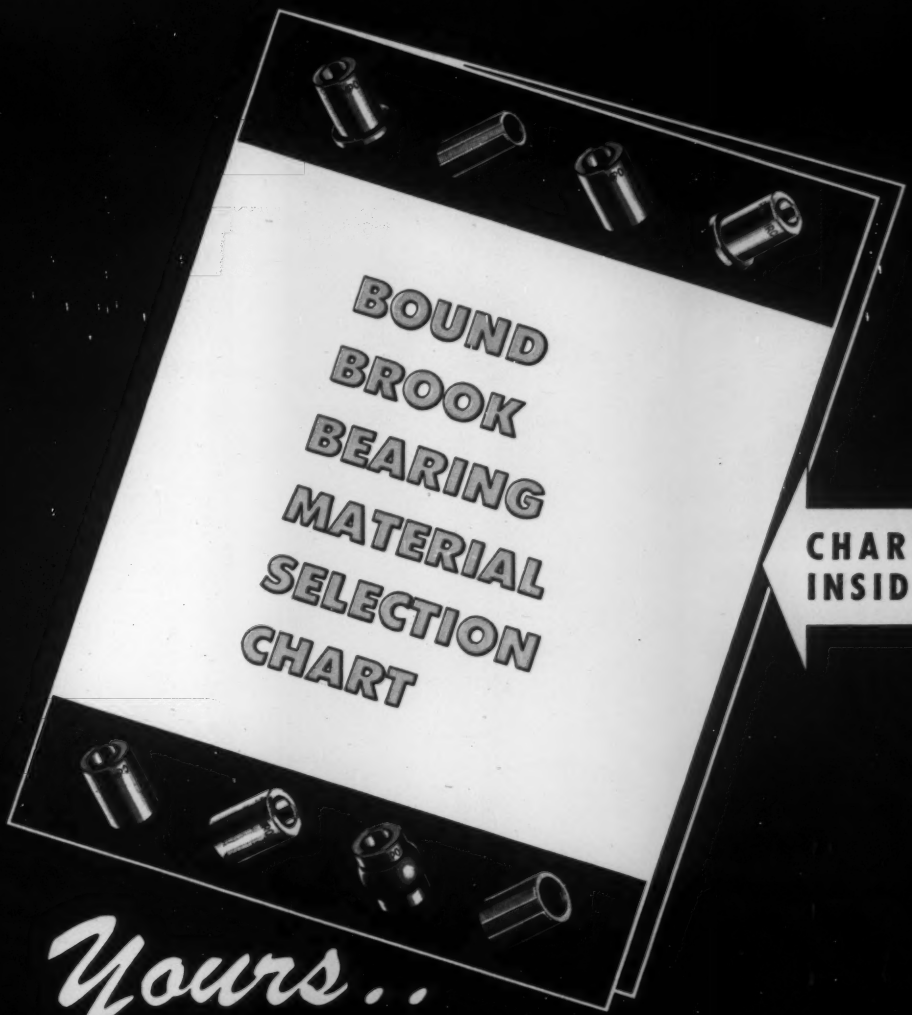
New roll for Machine Design was tried when Robert Lessing Jr., the son of MD production manager Robert Lessing Sr., entered this car in the Soap Box Derby. Young Bob's vehicle did not exactly lead

the pack of contenders ($W \sin \theta$ needs oiling). Before next year's contest we'll make sure that Papa Lessing takes home copies of MACHINE DESIGN, particularly issues containing articles on vehicle dynamics.

• • •

Versatile remote control for TV-radio-phonograph combinations, developed by Admiral Corp., does about everything but fetch the records to be played. Operating through ultrasonic waves, it can turn the TV or AM or FM radio on or off, adjust volume to four different levels, change stations, turn the automatic record changer on and off, and reject records.

Circle 407 on page 19→



Yours.. for the asking

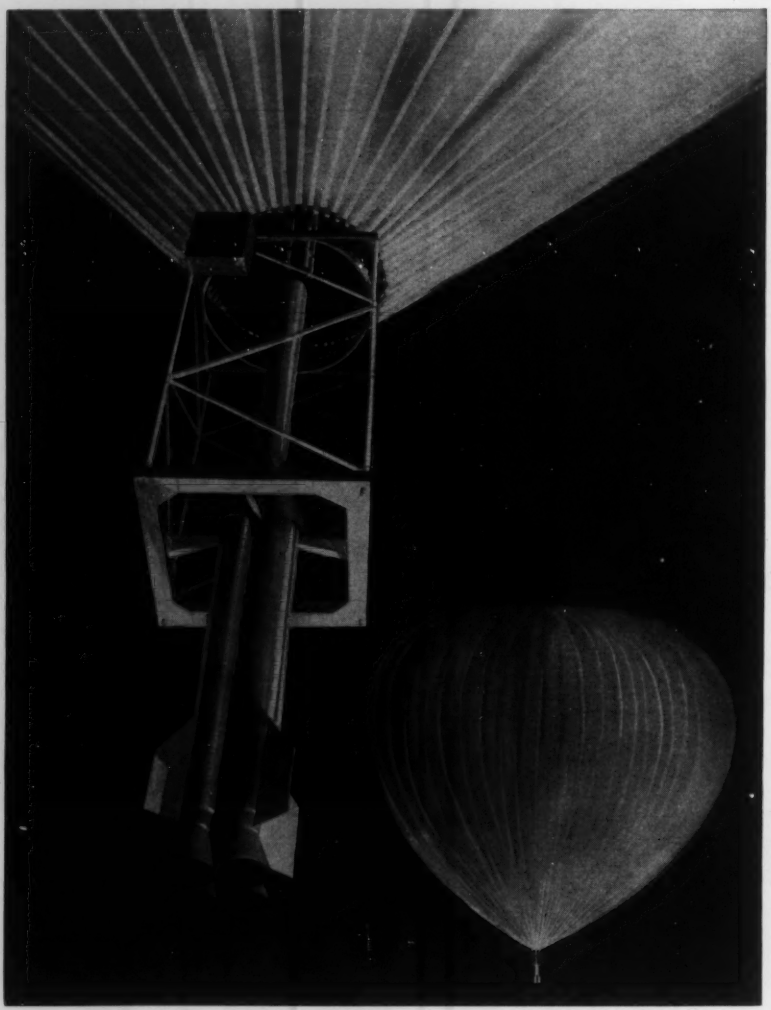
The proper material for sintered bronze or iron bearings has always been a major problem to design men. Now for the first time a chart has been engineered, clearly showing the complete chemical, mechanical, and work characteristics of a wide range of sintered bearing materials. The best material for most applications can be selected by a draftsman in a matter of minutes. Only requests on company stationary will be honored.

BOUND BROOK

BOUND BROOK OIL-LESS BEARING CO., EST. 1883, BOUND BROOK, N. J.

Pioneer in

POWDER METALLURGY BEARINGS + PARTS



Largest balloon ever launched will carry Far Side rocket to 100,000 ft for start of trip thousands of miles farther. Polyethylene envelope is 200 ft in diameter at rocket launching elevation, encloses 3,750,000 cu ft, weighs 1500 lb. Cargo weighs 2300 lb. Flights with dummy cargo were successful.

Rocket To Probe Space Thousands of Miles Out

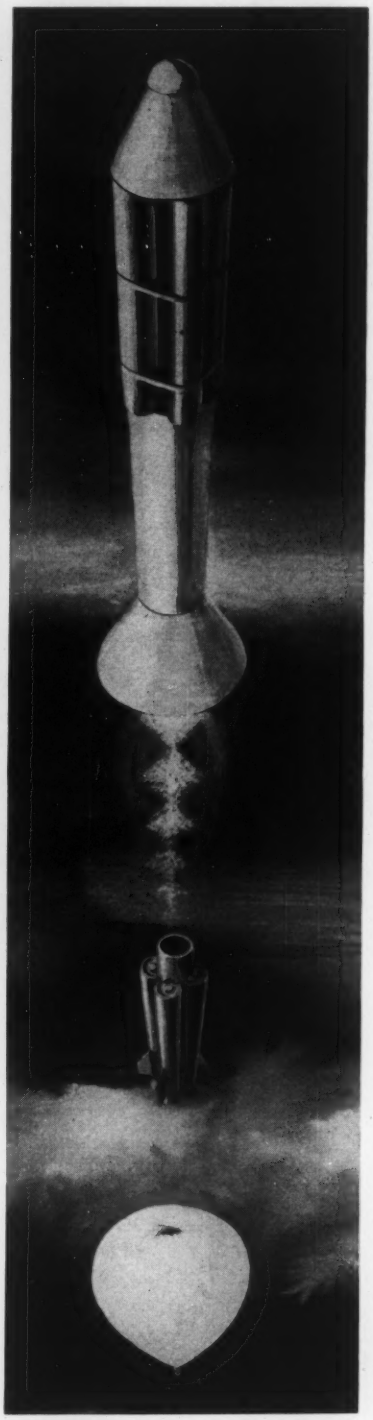
Launched at 100,000 Feet, Vehicle Will Travel 17,000 Mph

LOS ANGELES, CALIF.—Altitudes several thousand miles above the surface of the earth—higher than any man-made object has ever travelled—are expected to be reached by a new multistage rocket vehicle scheduled for launching in the next three months.

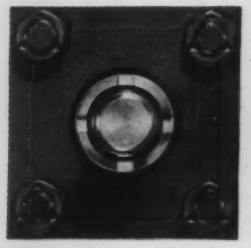
Development and launching of the vehicle is part of a program designated Operation Far Side, sponsored by the Air Force Office of Scientific Research. Prime contractor for the rocket and manager of the Far Side project is Aeronutronic Systems, Inc., a subsidiary of Ford Motor Co.

Purpose of rocket and program is to investigate atmospheric and space phenomena at extremely high altitudes. Far Side should also generate know-how for later experiments along the same lines.

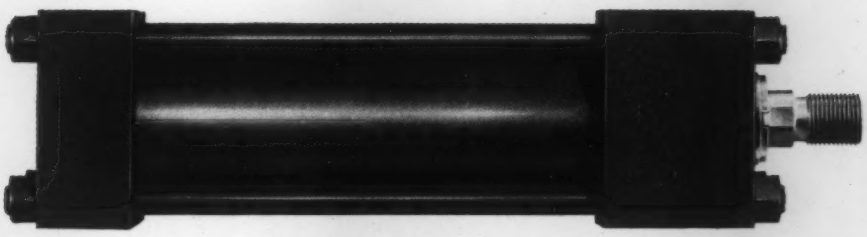
"First's" and superlatives characterize the present project. The largest balloon ever launched will serve Far Side as the first lighter-



At start of journey, Far Side rocket fires through top of its balloon, sheds first of four stages. Overall length is 23 ft; total weight, 1900 lb; maximum speed, 17,000 mph. Working cargo weighs 3½ lb.



Made for the tough buyer



The discriminating engineer is intolerant—intolerant of anything but the very best in his plant and in his product.

For these tough buyers Hannifin cylinders are made. Into these cylinders go original, exclusive features of design, precision manufacture, and the ability to outperform others with the very minimum of maintenance.

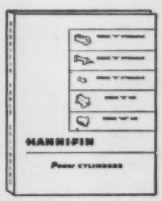
You would expect to pay more for Hannifin cylinders. Actually there is no price premium. We can deliver them to you promptly in the sizes and mounting styles you require.

AIR AND HYDRAULIC

HANNIFIN

POWER CYLINDERS

Write for your copy of this new Hannifin Cylinder File—complete, easy-to-use, easy-to-order-from information on five lines of Hannifin cylinders. Hannifin Corporation, 515 South Wolf Road, Des Plaines, Illinois.



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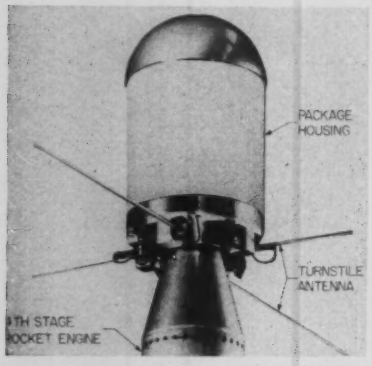
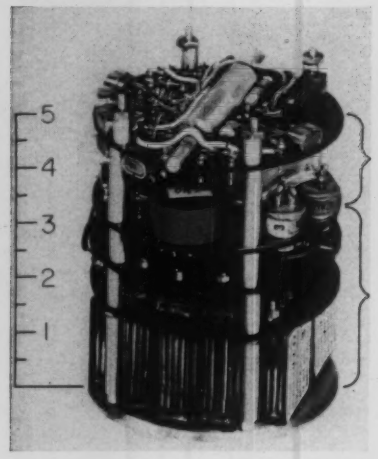
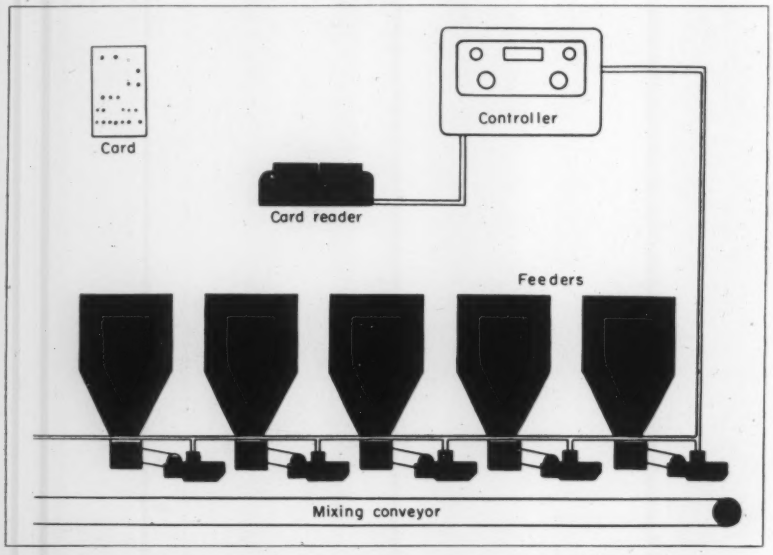


Instruments in the rocket's nose will measure cosmic rays, earth magnetism. They fit in package 6 by 4 in., weigh 3½ lb, have turnstile antenna which opens at burnout of fourth rocket stage.





PUNCHED-CARD FORMULA CONTROL for continuous-flow blending of multiple components, either liquid or solid, is said to assure product uniformity. Separate controlling device compensates for variation in component densities, maintaining formula accuracy to 0.1-per cent. Formula card for 35 components may be prepared in two minutes. Card reader senses binary code to activate electromechanical feeder drives. Programmed sequence of starting each component can be accomplished with timers. The system, developed by Graham Transmissions Inc., requires only card reader and feeder or pump drive, with control actuators, for most applications.

than-air rocket launching platform. The balloon will hoist the rocket to 100,000 ft, free from high drag of the lower atmosphere. Fired at that altitude, the rocket will shoot up through the envelope.

The rocket will travel faster than 17,000 mph. It is built in four stages and powered by solid propellant. The first stage consists of a cluster of four Recruit rocket engines; the second stage, a single Recruit rocket engine; the third stage, four Arrow II rocket engines; and the fourth stage, a single Arrow II rocket engine to which is attached the instrument package. The stages fire consecutively and separate from the vehicle after burnout.

Instruments in the rocket nose will transmit measurements of cosmic rays and earth magnetism. The instruments are enclosed in a 6 by 4-in. package and must withstand a maximum of 200 *g* for 26 seconds when the rocket's flight is powered. Weight of the instrument package is 3½ lb.

Ultrasonics To Dispel Smog, Dry Foods, Join Unlike Metals

METUCHEN, N. J.—Hygienic cleaning of medical instruments, smog abatement, and the joining of metals both like and dissimilar, are potential applications of ultrasonics discussed at recent seminars of the Industrial Education Institute. Leaders of the seminars were the heads of engineering departments at Gulton Industries, Inc.

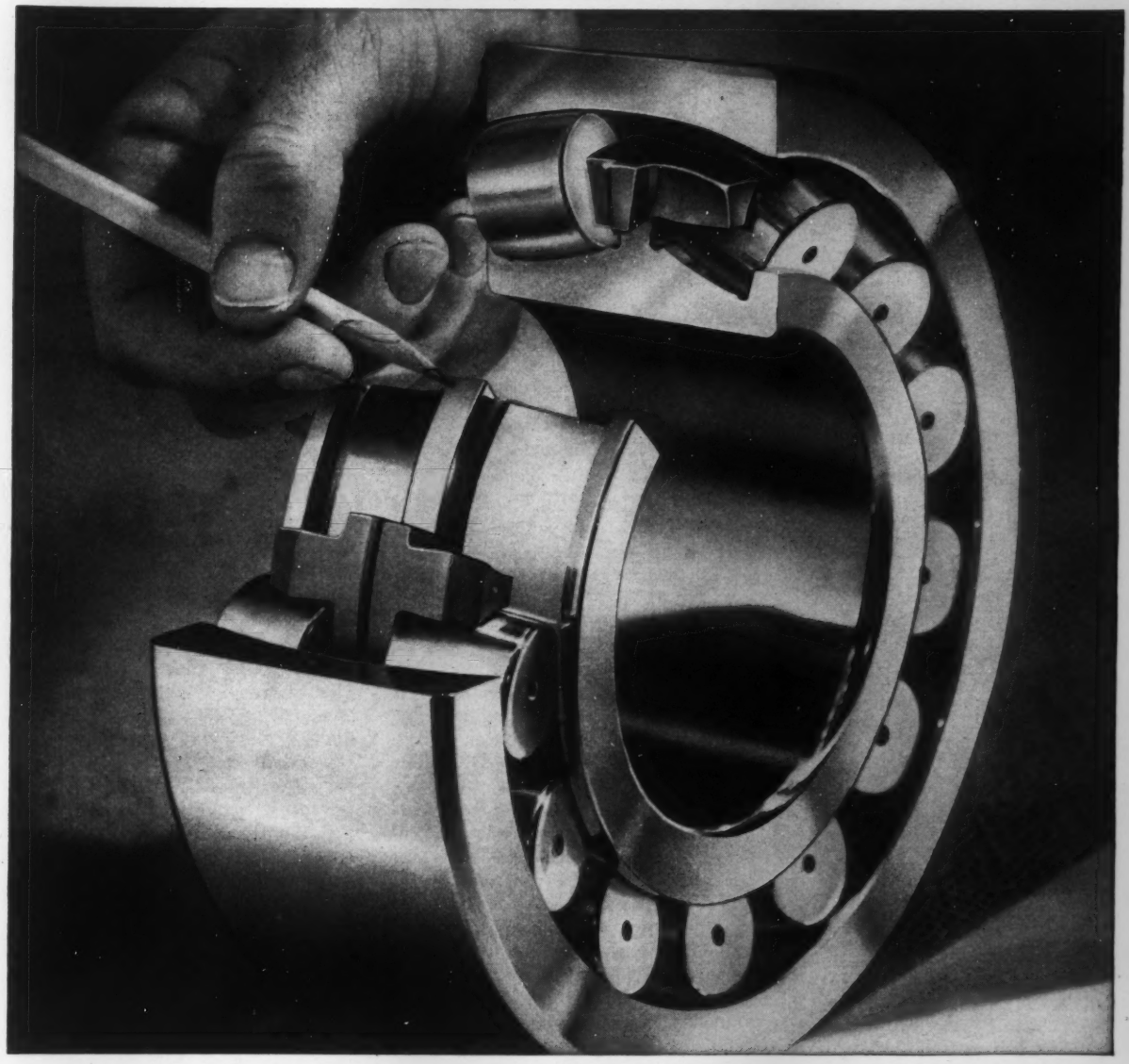
The use of ultrasonic waves in solids, gases and liquids was demonstrated with specific application to the chemical processing, industrial cleaning and aeronautical industries. Cold welding of aluminum and other lightweight metals can be accomplished ultrasonically, and recent developments promise widespread use in the joining of dissimilar metals such as aluminum and stainless steel.

The seminar leaders described work being done with multiwhistle sirens toward smog control and fog dispersion. Like dog whistles, the sounds of these sirens are inaudible to humans. By the principle of agglomeration, soot particles can be made to vibrate at intense ultrasonic frequencies, causing them to bump together and adhere. Because of this added weight the particles fall to the ground.

Other possible applications of the multiwhistle include acoustic drying of textile fabrics, pharmaceuticals, soap powders and foodstuffs. Drying of these materials must be accomplished without elevating temperatures more than a few degrees. The ultrasonic energy literally squeezes the moisture out of textiles, soap and coffee.

In medical practice, hypodermic

TORRINGTON *SPHERICAL ROLLER* BEARINGS



"This flange guides the rollers to peak performance!"

The center flange on the inner raceway of the TORRINGTON Spherical Roller Bearing positions the rollers to handle thrust loads. This accurate positioning also assures radial stability of the rollers under heavy loads—even at continuous high speeds and under conditions of misalignment.

This superior design feature is only one of many advantages you get when you specify TORRINGTON. For example, you get the service of TORRINGTON'S experienced engineers, who will help you with design and maintenance problems—or design custom bearings for special applications.

For long, low-maintenance service in heavy-duty applications, order TORRINGTON Spherical Roller Bearings. They're available from stock with either straight or tapered bore, for shaft or adapter mounting.

THE TORRINGTON COMPANY
South Bend 21, Ind. • Torrington, Conn.
District offices and distributors in principal cities of United States and Canada

TORRINGTON BEARINGS
Spherical Roller • Tapered Roller • Cylindrical Roller Needle • Ball • Needle Rollers

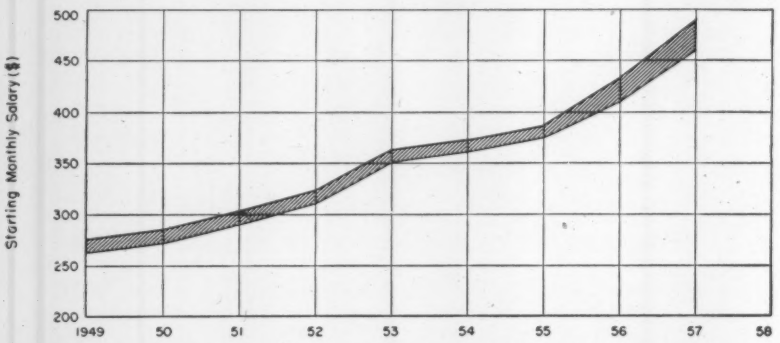
Circle 409 on page 19

needles and syringes clogged by dried blood or medications are normally difficult to clean manually. It is reported that ultrasonic industrial and medical cleaners, used with ordinary detergents, remove hard, dried substances in an instant on a single immersion.

One of the Gulton leaders, Dr. Paul Oncley, predicted that ultrasonic cleaning, presently the industry's largest commercial application, will become increasingly valuable in nuclear decontaminations. Experiments have proved it is possible to penetrate into the pores of a metal and clean or decontaminate it against radiation exposures.

THREE DIMENSIONAL MEASUREMENT is possible with this direct reading optical micrometer specially constructed by Naval Ordnance Lab. In addition to point location and measurement, profile surveys of an entire bearing can be made with the 150-lb instrument. Accuracy of ±0.0001-in. is maintained without exerting pressure on object being examined.

New nonprofit research foundation to be located in Columbus, Ohio has been announced by William C. Denison, its benefactor. The Denison Research Foundation will serve industry and the U.S. Government. Initial emphasis will be on projects in the electronic, mechanical, metallurgical, ceramic and management fields.



Steady rise in monthly starting salaries of new engineering graduates puts 1957 all-curriculum averages for nine schools in the range $460 to $490.

Roundup Feature Report

New Engineers' Starting Pay Still Trends Upward

Schools Report
10 to 12 Per Cent Gains

CLEVELAND, OHIO — For the eighth successive year, monthly starting salaries accepted by new engineering graduates have maintained a steady upward trend. In MACHINE DESIGN's annual spot check of the pay picture, schools throughout the country report that the class of 1957 is 10 to 12 per cent better paid to start than was the preceding group. Reports were received from California Institute of Technology, Case Institute of Technology, Columbia University, Lehigh University, Northwestern University, University of Pennsylvania, Purdue University, Stevens Institute of Technology, and Agricultural and Mechanical College of Texas.

Averages of monthly salaries for all engineering graduates in all nine schools occurred in the range $460 to $490. This range is slightly wider than the corresponding figures reported in 1956 and the limits are $50 and $65 higher, respectively.

In 1956 it was reported that mechanical and electrical engineers started at nearly the same salaries, a slight edge being given the electricals. That observation holds for 1957.

Ranges of averages for electricals and mechanicals are nearly identical to those for all engineers. Pay for aeronautical graduates tends to be higher than the all-curriculum average. Salaries slightly lower than the engineering average were accepted by chemists, chemical engineers, metallurgical and industrial graduates. The range for civil engineers is about 10 per cent above their 1956 figures.

General comparison of averages for all engineers with the averages for other graduates makes $400 per month a dividing line, with engineers on the higher side. This was also true a year ago. An exception is Columbia where business administration graduates have averaged $400 or more for three successive years; received $450 in 1957. Arts graduates generally trail the business men by small margins.

Several factors might be kept in mind in interpreting and evaluating the school returns. For one, placement directors advise that median figures are more revealing than averages (means). Averages tend to be higher than medians, but most of the differences in this survey tend to be less than $10. This is indicated by the results from Case. Significant differences may indicate wide variations in the desirability of graduates in the same class.

Starting salaries may also be affected by the changing volume of new blood in the profession. Since 1950, the first increase in the number of new engineering

graduates occurred in 1956, according to Engineers' Joint Council (see MACHINE DESIGN, June 13, 1957, Page 24). Still greater numbers can be expected this year.

Changes in demand for engineers in certain categories may also affect the pay picture for all graduates. Recent cancellation of certain Air Force contracts reversed a part of the engineer shortage in California almost overnight.

Finally, MACHINE DESIGN's annual survey, this year and last, shows that new engineers rank starting pay well below first place as an incentive for accepting their jobs. All schools that reported on factors influencing job selection state that the type of work offered is most important to graduates.

Other factors, approximately in order of importance, are: reputation of company, location of company, training programs offered, salary, size of company and company interviewing policies. This line-up is nearly identical to the survey findings in 1956.

Next year, placement should be less hectic for all involved—a slight tempering of demand and pay for new engineers seems to be the prospect.

New Heat-Resistant Alloys from Aluminum Powder Metallurgy

Extrusions, Forgings, Sheet For Military, Commercial Use

PITTSBURGH, PA. — New uses for aluminum in high-temperature applications are claimed possible through aluminum powder metallurgy. Various products made by subjecting the powdered metal to heat and pressure are now available commercially for the first time, according to the Aluminum Company of America, pioneer in the new process. Certain of the aluminum powder metallurgy (APM) products can withstand temperatures to 900 F, an advance of 300 to 400 degrees above the point at which conventional aluminum alloys function efficiently.

The new APM products are made from fine, unalloyed aluminum

(*Continued on Page 22*)

DRAFTING TRENDS

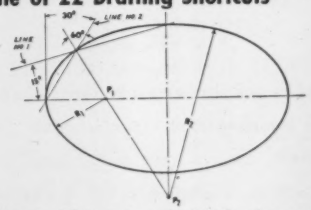
This free booklet, newly developed by the Frederick Post Company through the co-operation of leading engineers and draftsmen, shows 59 shortcuts to speed drafting and computation work.

Ideas for increasing drafting and engineering efficiency

POST went to leading engineers and draftsmen and asked them what techniques they use to save time without sacrificing precision in their work. From the many interesting tips and drafting shortcuts suggested, a total of 59 have been compiled into one handy booklet called "Time Saving Tips for the Draftsman and Engineer."

Clearly written and well illustrated, this booklet shows new approaches to old problems. The section on CALCULATING IDEAS contains 10 tips including easy ways of "Remembering the Signs of Trig Functions," "Dividing a Circle Into Parts," and "Locating Decimal Points."

One of 22 Drafting Shortcuts



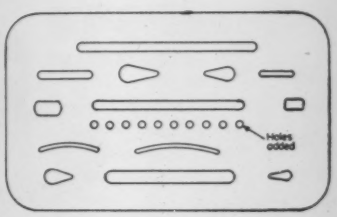
Here is what seems to be the fastest and easiest method of constructing an approximate ellipse: (1) Draw a line at 15° to major axis as shown. (2) Draw a line at 30° to minor axis as shown. (3) Draw a line at 60° to line #2 through intersection of lines #1 and #2. (4) Draw Arc R_1 from point P_1. (5) Draw Arc R_2 from point P_2.

9 tips in Engineering Data Section

Easy-to-use, practical shortcuts to formulas and other engineering data are featured in this section. Two of these time savers are faster methods of "Determining Gear Inertia" and "Interpolating Between Family of Curves."

One of 18 Board Timesavers

Fairly often when drafting it becomes necessary to change a solid line to a dotted line. By placing a series of holes in an erasing shield, as shown, it is possible to make the conversion simply by erasing through the holes.



For your free copy of "Time Saving Tips for the Draftsman and Engineer," contact your POST dealer or write today to the Reader Service Division of Frederick Post Company, 3652 N. Avondale Avenue, Chicago 18.

POST

SENSITIZED PAPERS & CLOTHS • TRACING & DRAWING MEDIUMS • DRAWING INSTRUMENTS & SLIDE RULES
ENGINEERING EQUIPMENT & DRAFTING SUPPLIES • FIELD EQUIPMENT & DRAFTING FURNITURE

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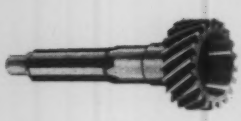
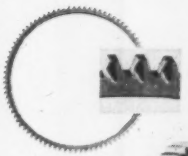
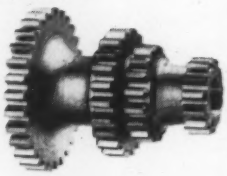
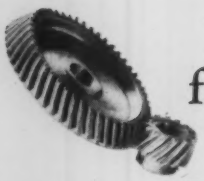
DOUBLE DIAMOND GEARS ARE BUILT...

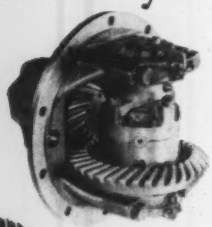


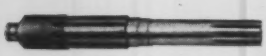
...to produce low installed cost

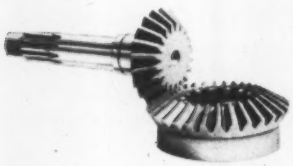
...to serve economically  and

dependably on the job 

 for which you buy them

...and to do  credit to your product



and reputation 

The gear types shown above include helical gears, flywheel starter gears, straight bevel gears, straight spur gears, angular bevel gears, hypoid bevel gears, gear assemblies, zerol* bevel gears, spiral bevel gears, and spline shafts. Those are the types in which we specialize. Our sales people are gear engineers. Would you like to talk to one?

* Reg. U. S. Pat. Off.

EATON

AUTOMOTIVE GEAR DIVISION
MANUFACTURING COMPANY
RICHMOND, INDIANA

GEARS FOR AUTOMOTIVE, FARM EQUIPMENT AND GENERAL INDUSTRIAL APPLICATIONS
GEAR-MAKERS TO LEADING MANUFACTURERS

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EDITORIAL CLIPSHEETS—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and title of article in the place provided on the Yellow Card.

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419	444	469	494	519	544	569	594	619	644	669	694	719	744	769
420	445	470	495	520	545	570	595	620	645	670	695	720	745	770
421	446	471	496	521	546	571	596	621	646	671	696	721	746	771
422	447	472	497	522	547	572	597	622	647	672	697	722	747	772
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Cleveland 13, Ohio

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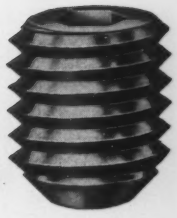
how to keep costs down



...profit margins up!

ALLEN Engineers will show you how you can save time and money by using standard* ALLEN Hex-Socket Cap and Set Screws instead of specials.

Let's get this straight right away... if your product design MUST have special cap or set screws, then ALLEN's the place to come for them.

But our engineers have found, from a good many years of experience, that designs frequently call for *special* hex-socket cap and set screws that are only slightly "off-standard." These specials take longer to get, cost more.

Allen engineers can probably save *you* both time and money by working with you on ways to use *standard* Allen Hex-Socket Cap and Set Screws, where specials may seem to be necessary. Just send blue prints, or good descriptions, of your product designs to our Engineering Department, or talk with your Allen Field Representative.

***ALLEN manufactures 1457 *standard* items**

Stocked and sold by leading industrial distributors everywhere

ALLEN MANUFACTURING COMPANY
Hartford 2, Connecticut, U.S.A.

ALLEN HEX-SOCKET SCREWS HEAD

NO INTERFERENCE from other communications systems in the same busy 450-470 mc frequency band is the feature this two-way radio developed by Motorola Corp. The new mobile equipment transmits a continuous subaudible hum along with voice transmission. Receivers "open up" for listening only when proper tone is transmitted, shutting out all reception except that being originated by the dispatcher or other mobiles in the same system.

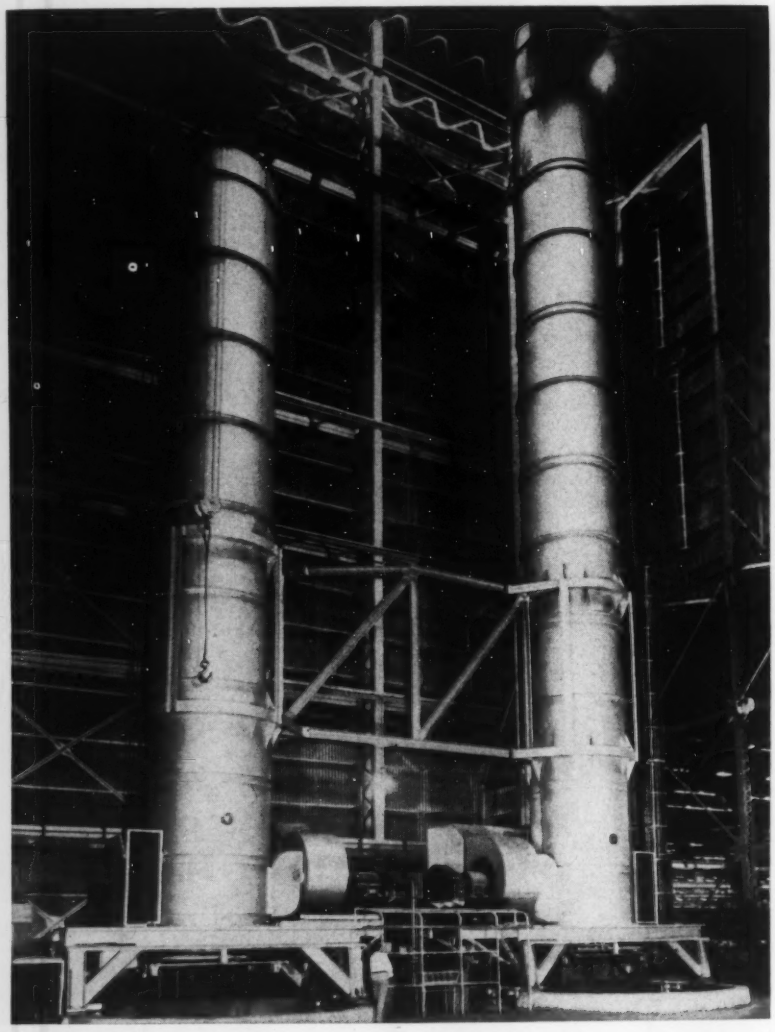
(*Continued from Page* 15)

powder, each particle coated with aluminum oxide. When the powder is compacted and worked, the oxide coating greatly strengthens the part and contributes stability at elevated temperatures.

APM products are claimed easier to fabricate than titanium and have much higher thermal conductivity than either titanium or stainless steel. Where friction is encountered in certain engine components, the new products can be anodized, insuring a hard oxide coating that prevents moving parts from sticking. Electroplating by regular methods is possible and the products have high resistance to recrystallization and to overheating.

Three APM alloys are available. One alloy is made of domestic aluminum powders; the other two use powders imported from Switzerland. Formulas were not disclosed.

The new alloys are being tested in a number of applications. Metal and foil are tested for making honeycomb sandwich structures. Extrusions have been used for hot-air valve housings. Tube is being considered for airborne heat exchangers; while fasteners—rivets, screws, nuts and bolts—are being tested for a number of applications.



LARGEST OF ITS TYPE, the 110-ft high, 7-ft diam furnace (right) heat treats extruded aluminum alloy shapes up to 80 ft long at temperatures as high as 800 F. At the end of the heating cycle, a door at the bottom of the furnace is opened, and the parts are plunged into an underground quenching tank 110 ft deep and 18 ft in diam. The furnace was built by Westinghouse for Harvey Aluminum Co., as was its 70-ft high companion (left).

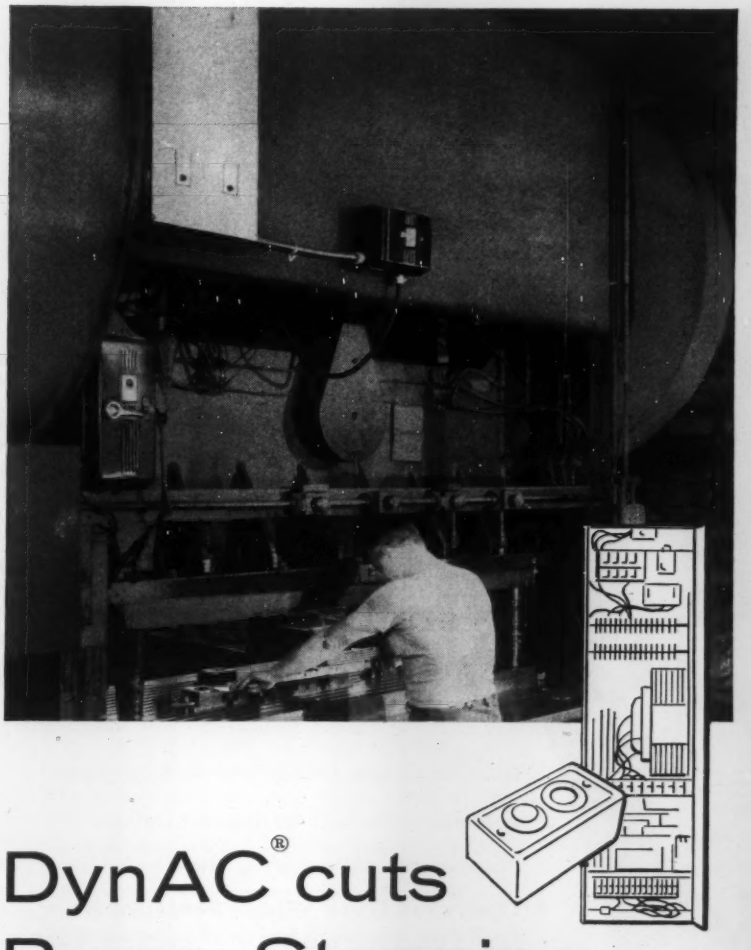
Film Strip Radar Mapper Shows Airman Where He's Been

Rapid Film Developing Provides Ground Picture in 20 Seconds

PASADENA, CALIF.—Airplane pilots and navigators can now consult a map that is only twenty seconds old, made night or day, in flight, by radar. A device called a radar strip recorder makes an actual photographic record of radar information on a slowly-moving strip of film. The transparency pictures the ground immediately aft of the airplane, exactly as it looked to the plane's own radar twenty seconds earlier.

The new automatic device requires no operator. As a navigation aid, it can help to determine easily an airplane's exact position and true flight path. Manufacturer is the Hycon Mfg. Co.

The strip recorder with its as-



DynAC® cuts Press Stopping Time 95%

The eight minutes it previously took to stop the heavy flywheel on this press has been cut to an amazing *24 SECONDS* with Westinghouse DYNAC.

This press is now getting the fastest, smoothest stops possible —increasing production, with no unusual wear.

Because DYNAC is completely electrical, it is simple to install. No costly fittings and troublesome mechanical apparatus. The compact, self-contained unit can be installed anywhere, at machine or for remote operation.

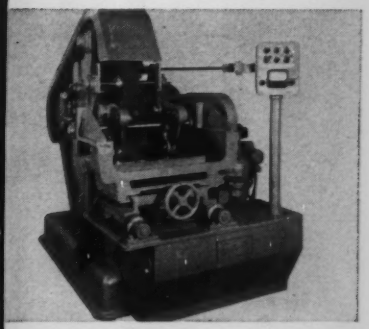
DYNAC is giving fast, smooth moneysaving stops on many applications throughout industry. Call your Westinghouse representative or distributor. Or, write Westinghouse Electric Corporation, 3 Gateway Center, Pittsburgh 30, Pennsylvania.

J-22000

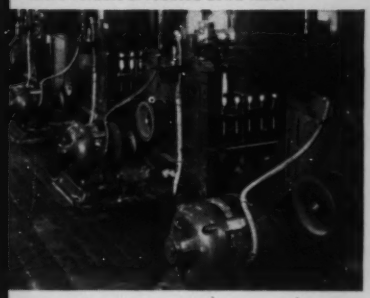
YOU CAN BE SURE...IF IT'S

Westinghouse

HERE ARE SOME TYPICAL APPLICATIONS:

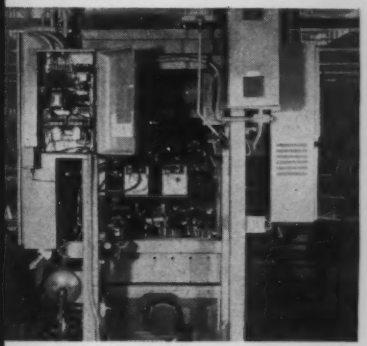


GRINDING MACHINES with DYNAC produce more because of reduced down time.



SPINNING FRAMES with DYNAC have saved owners over $3,000 per year per 100 frames.

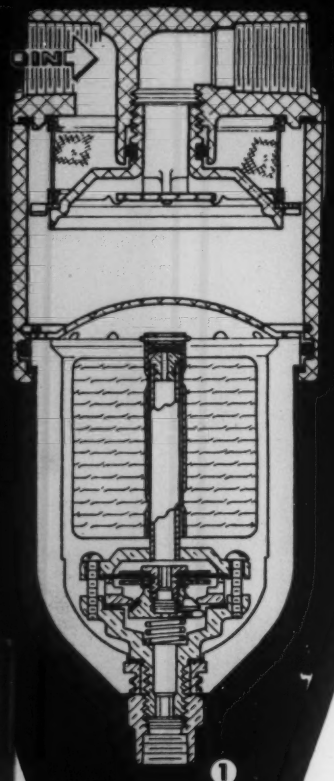
CONVEYORS using DYNAC can be stopped once a minute, day in and day out, with no maintenance.



AUTOMATIC WELDERS with DYNAC can complete 600 operations per hour—20 stops per minute—24 hours a day.

Circle 413 on page 19

NEW Advanced design Norgren AUTOMATIC-DRAIN AIR LINE FILTERS



1 MORE EFFICIENT WATER REMOVAL

2 WIDER OPERATING RANGE 5 psi to 250 psi, up to 200° F.

BETTER... MORE EFFICIENT FILTRATION OF COMPRESSED AIR

You Get These Important Advantages:

- **More Efficient Water Removal**
  Greatly increased water removal efficiency—even at air flows 143% higher than ever before.
- **Operates Over Wider Pressure Range**
  Top efficiency at as low as 5 psi for all models and as high as 250 psi for metal bowl type.
- **Operates Over Wider Temperature Range**
  New metal bowl models in ¼", ⅜" and ½" sizes extend temperature range to 200° F.
- **Withstand Rougher Usage**
  Metal bowl models are ideal for applications likely to get rough usage.
- **Simplified Drain Mechanism**
  More efficient operation. Fewer parts.
- **Eliminates Manual Draining**
  Collected liquid is drained automatically—cannot return to air line. Drain operates as long as pressure is on the system.
- **Choice of Three Filter Elements**
  74, 64 or 25 micron elements—interchangeable.

NOW—24 Models to choose from

- Transparent Bowls—¼", ⅜", ½", ¾", 1"
- Metal Bowls—¼", ⅜", ½"

Wherever Air is Used in Industry

C. A. NORGREN CO.

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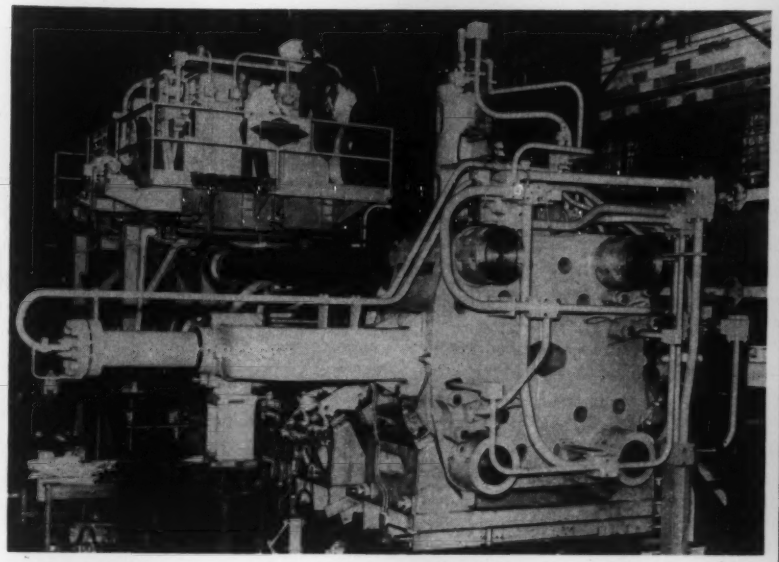
For complete information, call your nearby Norgren representative listed in your telephone directory—

OR WRITE FACTORY FOR NEW NO. 800 CATALOG

Circle 414 on page 19



FAST-ACTING EXTRUSION PRESS for aluminum is claimed to reduce dead cycle time. Four radial-piston pumps driven by two 350-hp motors deliver oil in variable quantities to press components. Fixed and variable position limit switches control motors to assure precise sequence operation. Result is said to be rapid, integrated operation of all press components for optimum speed of press operation. In event one of the pumps fails, press will operate on the remaining three. Unusual die slide arrangement provides an alternate die location for inserting, removing, dressing or adjusting a second die while extrusion continues uninterrupted on the first die. The machine is a recent product of Birdsboro Steel Foundry & Machine Co.

sociated fast film processor is adaptable to nearly all types of airborne radar. In addition, it is useful as a ground recorder of radar or telemeter information relayed from flying radar sets. In this way the strip recorder can function as an automatic monitor for a missile or drone aircraft.

Essential in the recorder is a unique process evolved by Hycon for developing high-sensitvity film in only 10 seconds. The process uses only one liquid bath which functions at a high temperature to speed film development. The liquid is wiped onto 9-in. wide film much the same as walls of a house are painted with a squeegee. The resultant transparency is then viewed on a translucent lighted screen about 9 by 12 in. in size.

Either of two areas of coverage can be selected. If a 45 by 60-mile area is scanned, the resulting map has the scale of 1:500,000. If a 22½ by 30-mile area is chosen, map scale is 1:250,000.

DEW Line Completion Marks Beginning of Arctic Defense

WASHINGTON, D. C.—Successful completion of preoperational tests on the 3000-mile Distant Early Warning Line in the Arctic has been announced by the Air Force. The system was constructed under Canadian-U. S. agreement, with Western Electric Co. as prime contractor. It was accepted and placed on an operational basis July 31, 1957. Installation began late in 1954 and was completed in 32 months on schedule.

Stretching from western Alaska across the upper rim of the North American continent, through Canada to Baffin Island, and lying entirely above the Arctic Circle, Dew Line will provide the U. S. and Canada with advance warning of the approach of airborne objects over the polar regions, allowing the greatest possible time margin.

Operation and maintenance of

Do you think about angular acceleration?
CONVAIR
Division of General Dynamics Corporation
does . . .
B-58 Hustler . . . the first supersonic bomber for the United States Air Force.
Statham liquid rotor angular accelerometers are rugged and reliable. They may be ordered with either an unbonded strain gage or inductive pickoff and are available in ranges from ±1.5 to ±3,000 rad/sec².
Please request our Accelerometer Catalog and Instrument Notes No. 26 "Some Design Considerations For Liquid Rotor Angular Accelerometers"
Statham
LABORATORIES
LOS ANGELES 64, CALIFORNIA

Circle 415 on page 19

the line will be done by International Telephone & Telegraph Corp. under Air Force supervision.

REMOTE VALVE-POSITIONING control, developed by Sparton Corp., provides audible signals of upper and lower valve limits plus meter indication of valve position. System is designed to operate with present motor controllers. Two independent visual alarms show power failure, pressure, temperature or overload.

Mechanisms Conference To Report European Progress

CLEVELAND, O.—A comprehensive survey of mechanism design in Europe will be the start of an outstanding program planned for the Fourth Mechanisms Conference. Mr. Kurt Hain, prominent German scientist and design engineer, will travel to this country to present the first paper before the Conference on Monday, Oct. 14.

The conference is cosponsored by Purdue University and MACHINE DESIGN. It will be held on the Purdue campus, West Lafayette, Ind., Oct. 14 and 15.

In addition to his opening-day presentation, Mr. Hain will present a paper on drag-link mechanisms. His extensive background includes research and design on machine tools, aircraft, typewriters and computers. During the past 25 years he has published two books and prepared more than 200 papers for publication in technical journals. He is currently engaged in kinematic research in the engineering of agricultural machinery at the Institut Fur Landtechnisch Grundlagenforschung in Braunschweig, West Germany.

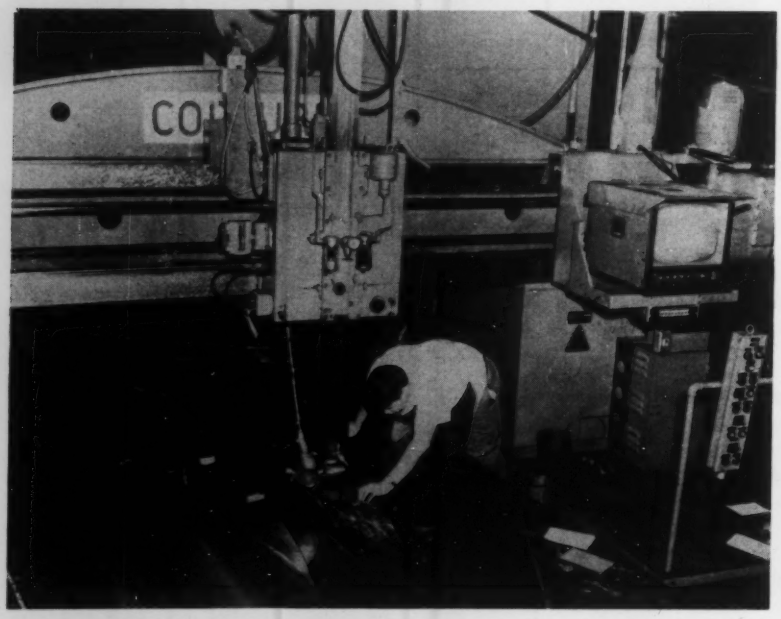
More than ten papers, ranging in subject from practical approaches to design and application of cams and linkages to advanced concepts of analysis and synthesis of mechanisms, will round out the most complete program in the history of the Conference.

Complete program details as well as registration and room-reservation forms for the Conference will appear in the next issue of MACHINE DESIGN. Registration fee of $25 includes banquet, luncheon and transactions.

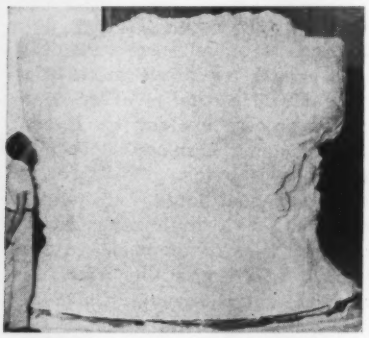
Rooms will be available at the Memorial Union on the Purdue Campus and at hotels and motels in Lafayette.

Conference members can reach Lafayette by Lake Central Airline from Chicago and Indianapolis, New York Central Railroad through Chicago and Indianapolis and Wabash Railroad from St. Louis and Detroit.

Further details of program and registration will appear in the next issue of MACHINE DESIGN.

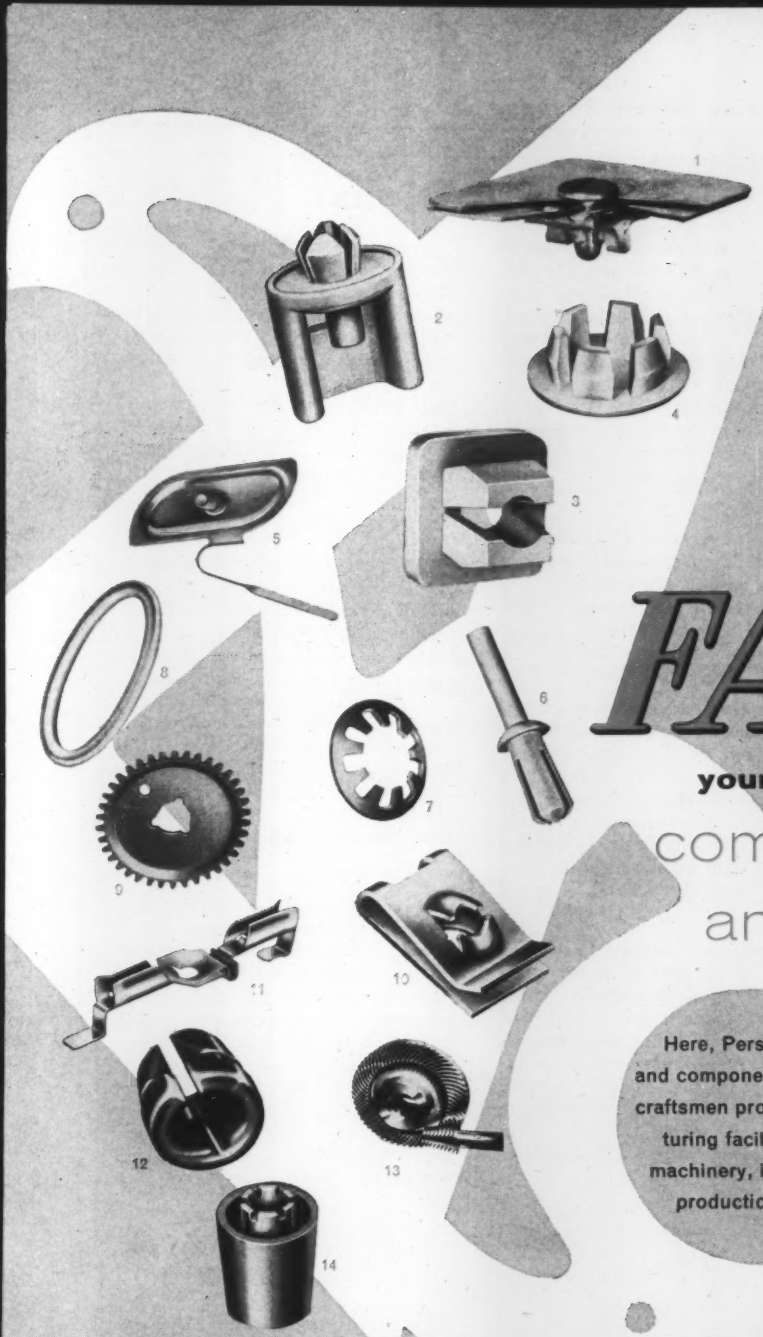


TELEVISED SCRIBINGS enable operators of this die layout machine, first of its kind, to prepare dies up to 10 ft in width, 22 ft in length, more than 3 ft in thickness. Television cameras focus on three vernier scales; constantly track the machine's scriber which is capable of motion in three dimensions. TV receiver on operator's bridge displays images ten times actual size. It has one channel for each of three machine motions. Televised readings enable construction of lines that guide die-sinking tools. The out-size scriber prepares dies for presses in the Cleveland Air Force plant operated by Alcoa.



LARGEST COMMERCIAL MELT of synthetic mica was recently completed by Synthetic Mica Corp., using more than 80,000 lb of raw material. The mass must cool three weeks. Synthetic mica has proved superior to the natural material for applications involving temperatures in excess of 1000 F.

Circle 416 on page 19→



FASTEX

your source for savings in

component design and production

Here, Perspective Engineering conceives and creates fasteners and components of metals and plastics for mass-assembly. Skilled craftsmen produce these parts by the millions in integrated manufacturing facilities. Through this unique combination of talent and machinery, industry is served with maximum design flexibility and production speed. Assembly time is saved, costs are reduced.

FASTEX® PARTS PICTURED ABOVE ARE: 1. Q Fasteners (T.M.), fasten with a quarter turn. 2. Plasti-Supports (T.M.), blind-assembly shelf supports. 3. Plasti-Grommets®, self-retaining blind screw receptacles. 4. Plasti-Plugs® improve product appearance. 5. Molding Clips are self-adjusting, vibration proof. 6. Plasti-Rivets®, one-piece, self-expanding for blind assembly. 7. Springrip Fasteners with internal teeth. 8. Plasti-Rings®, self-retaining plastic shaft retainers. 9. Precision Stamped Gears, complete range of types and sizes. 10. Speed Nuts®, economical self-retaining nuts. 11. Engineered Stampings speed assembly. 12. Plastinite® one-piece strain-relief grommets. 13. Nylon Spiroid® Gears offer new space and weight economies. 14. Engineered Molded Plastic Parts, low-cost, time-saving.

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Circle 417 on page 19

Defense Digest

Solar batteries may power Army's experimental helmet radio. Solar cells in combination with nickel-cadmium batteries are expected to produce one-year power supply. Transistorized power converter raises 4.5-v output of solar-nickel-cadmium combination to 50 v necessary for receiver-transmitter operation. Helmet and radio combined weigh 2 lb, 11 oz.

• • •

Take-off distance of Lockheed's C-130 military transport has been reduced to half the normal 800 to 1000 ft. Using JATO, the 80,000-lb plane travels 500 ft in 4 seconds to become airborne.

• • •

Nose cone development of intercontinental missile Titan will be undertaken by Avco Mfg. Co. under recently awarded $111-million Air Force contract. Size of contract denotes seriousness of design problem. Missile will reportedly travel 18,000 mph, encounter temperatures to 15,000 F.

• • •

Transparent silicone rubber forms interlayer of safety-glass "sandwich" in windshield panels of B-58 bomber. Conventional plastic interlayers would melt at temperatures encountered by the exceptionally high-speed aircraft. Developed by Dow Corning Corp., new interlayer is claimed to be first commercially available transparent rubber.

Snark intercontinental missile has been ordered into production for delivery to operational units of Strategic Air Command. Produced by Northrop Aircraft Corp., the missile is designed to carry nuclear warhead and can be launched from stationary or mobile launcher. Snark is 69 ft long, 15 ft high, has 42-ft wing span. Power is furnished by single Pratt & Whitney J-57 turbojet engine.

• • •

First electronically - automated ground control intercept system, for air defense, has been developed by Columbia University. Using an anolog computer, system furnishes signals which are incorporated into fire control system of interceptor aircraft, automatically guiding the craft to "terminal point." Signals may be transmitted verbally to pilot if desired. Previous systems provided signals which could only be relayed verbally.

• • •

Major armament of Navy's first nuclear - powered cruiser, *Long Beach*, will be surface-to-air guided-missile Talos. Three additional cruisers are currently being modified to carry the missile. Talos is guided by mechanical system, detonated by proximity fuse. Ramjet engine that powers the weapon has proved so successful that no design change in engine has been made in four years of testing the missile.

Flame-Arresting Muffler Eliminates Fire Hazard

FORT BELVOIR, VA.—Spark and flame-arresting muffler to reduce fire hazards caused by truck exhaust in congested and highly combustible areas, has been developed by Army Corps of Engineers.

Capable of complete suppression of backfired spark and flame, the device is designed primarily for gasoline-powered fork-lift trucks, but is adaptable to other gasoline powered vehicles using pusher type cooling fans. In tests utilizing the new unit, exhaust-gas temperature at outlet was 240 F, well below the 350 F max. allowable in warehouses and other storage spaces. Sound-level readings were on par with those of conventional mufflers.

Unit consists of two separate sections: muffler and spark-flame arrester. Muffler is a single perforated tube in an increased volume chamber with the exit gas tube and one head welded in position to the muffler shell. In the air-dilution type arrester, exhaust gases are cooled by dilution with air leaving the engine radiator. Housing is mounted so that the

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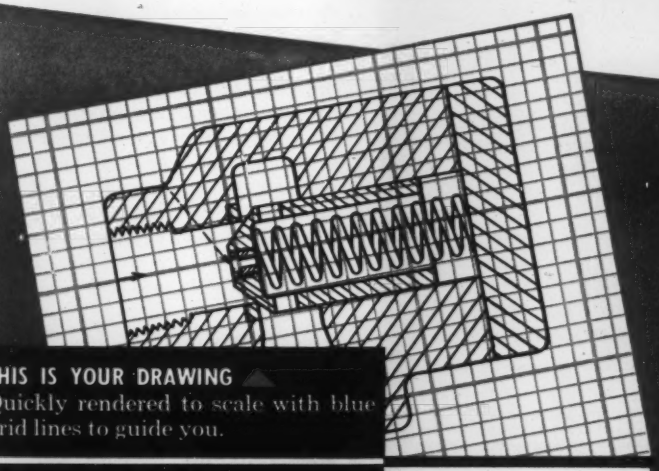

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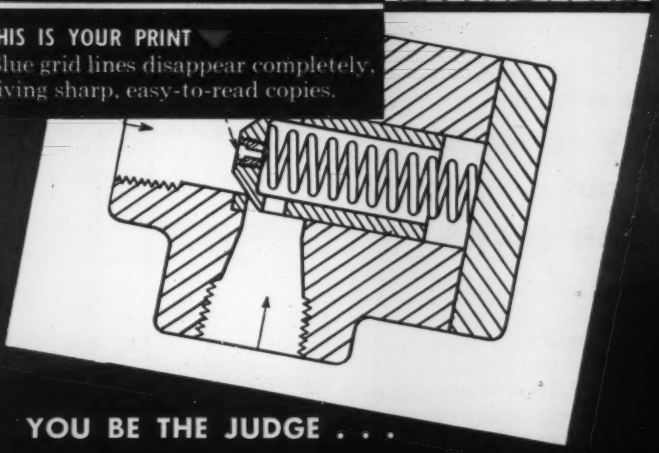

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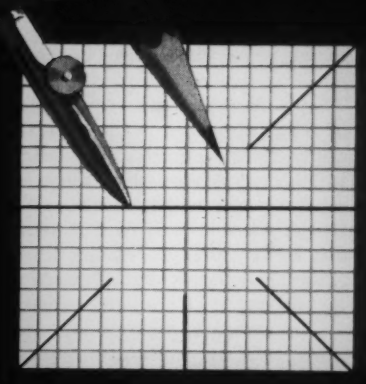

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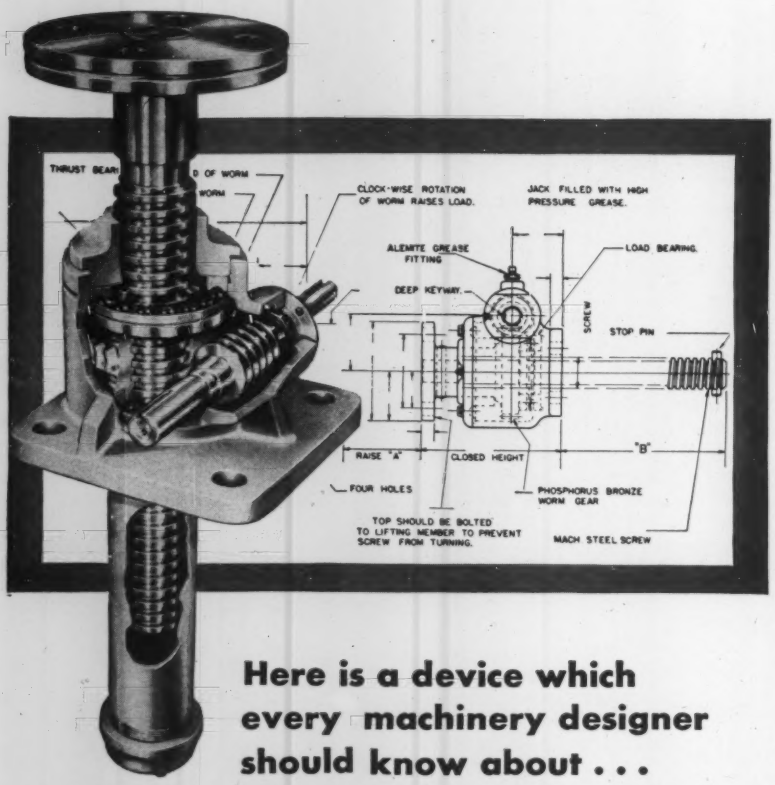
Circle 418 on page 19



Here is a device which every machinery designer should know about . . .

DUFF-NORTON WORM GEAR JACKS

Duff-Norton worm gear jacks provide a purely mechanical means for accurate positioning of loads weighing as much as several hundred tons and maintaining them indefinitely without creep. They will operate in any position, and functioning as components of machinery and equipment they can raise and lower loads, apply pressure or resist impact. Jack capacities range from five to 50 tons. When two or more jacks are connected by means of shafting and mitre gear boxes they lift in unison, even when the load is unevenly distributed. They are available with standard raises up to 25 inches, and will provide exactly the same raise for years without adjustment. Worm gear jacks are suitable for operation at ambient temperatures up to 200°F.

Thousands of these jacks are in use on feeding tables, tube mills, welding positioners, pipe cut-off and threading machines, testing equipment, aircraft jigs, loading platforms, rolling mills, conveyor lines, arbor presses, and numerous other types of equipment. If you have a positioning problem, write for complete information, requesting bulletin AD-34-V, which includes drawings and full specifications.

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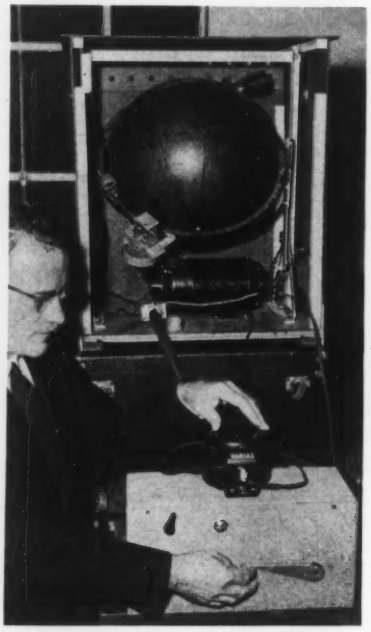
News Roundup

top coincides with top of the radiator core. Maximum air from the fan is thus utilized to dilute hot exhaust gases before they exit through filter. Soot-collecting chamber is flanged and bolted to the arrester housing for ease of removal through radiator grill. Although the two units were developed in combination, the arrester in most cases may be attached to an existing muffler. Muffler and arrester are manufactured by Fluor Corp.

Earthbound Space Flight Job For Satellite Simulator

FORT BELVOIR, VA.—A device for simulating the actual flight path of a space vehicle has been developed by an engineer at the Corps of Engineers' Research and Development Laboratories.

Called "Panatrack," the device projects a moving view of the terrain over which the vehicle "flies,"



U. S. Army photograph

showing the area as it would be seen by an observer in a space ship or satellite.

The apparatus developed by Edward J. Madden, consists of a projector inside a globe, that can be positioned automatically to

show on a screen any portion of the earth's surface either at rest or in motion. The rate and direction of motion is adjustable as desired.

As a satellite tracking display, its drive motors could be controlled by signals transmitted from the real satellite and processed through ground stations so that the current position of the vehicle is continuously displayed on a screen.

It is expected that public interest in any space flight activity will demand some means of showing the actual event to interested groups.

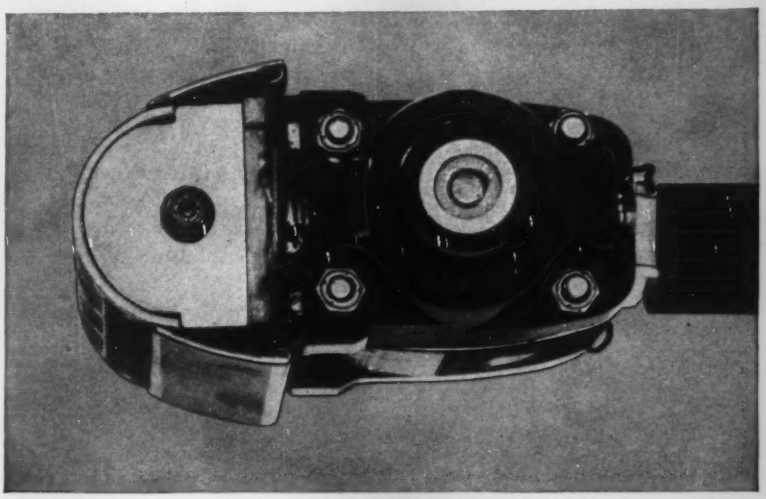
LARGEST, MOST POWERFUL permanent magnet, built by Indiana Steel Products Co., will be used in a new mass spectrometer. Weighing 1300 lb, the aluminum-nickel-cobalt-iron alloy magnet can establish a magnetic field of 6000 gauss in its air gap—equal to 10 tons force.

Hard-Hitting Gatling Gun Under Test by Air Force

WASHINGTON, D. C.—A new, larger calibre version of the high speed T171 Vulcan machine gun (MACHINE DESIGN, Nov. 15, 1956, Page 6) has been developed by General Electric Co. under Army Ordnance contract for the Air Force.

Called the Vulcan T212, the new gun is a 30-mm version of the T171 20-mm "Gatling gun," employing

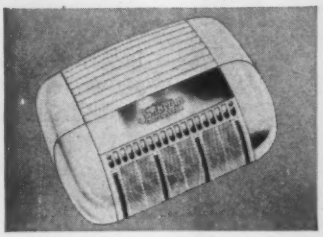
FASTENER PROBLEM



Self-locking fasteners for limited clearance applications

The cutter shaft of the Sunbeam Electric Shaver moves the cutting blades at about 9000 RPM. The double nuts previously used to fasten the pitman arm to this shaft had to be really tight. With the pressure of high volume production, improper tightening sometimes caused bent shafts—and frequent thread stripping.

A single true miniature ELASTIC STOP® nut, only .080" high and .125" across flats (ESNA No. 99-1660-12, 1-72 thread) is used to replace the double nuts. The action of ESNA's red elastic locking collar permits locking anywhere on the shaft for simple and completely accurate adjustment . . . and eliminates thread stripping. This simple, direct locking action avoids production-time losses due to bending; and saves the cost of the rejected shafts as well.



A separate series of reduced-dimension hex nuts are used on the "field" studs fastening motor to frame (ESNA No. 99-2399-38). This size 3-48 nut is .130" high and .187" across flats. The stop nut eliminates lock washers and further shortens assembly time. Solution of this multiple fastener problem illustrates ESNA's ability to supply an efficient, vibration-proof, self-locking fastener to meet almost any dimensional requirements.

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ESNA

Dept. N91-84 Elastic Stop Nut Corporation of America
2330 Vauxhall Road, Union, New Jersey

Please send me the following information:

☐ Details on ESNA miniature and reduced dimension nuts

☐ ELASTIC STOP® nut bulletin

☐ Here is a drawing of our product. What fastener would you suggest?

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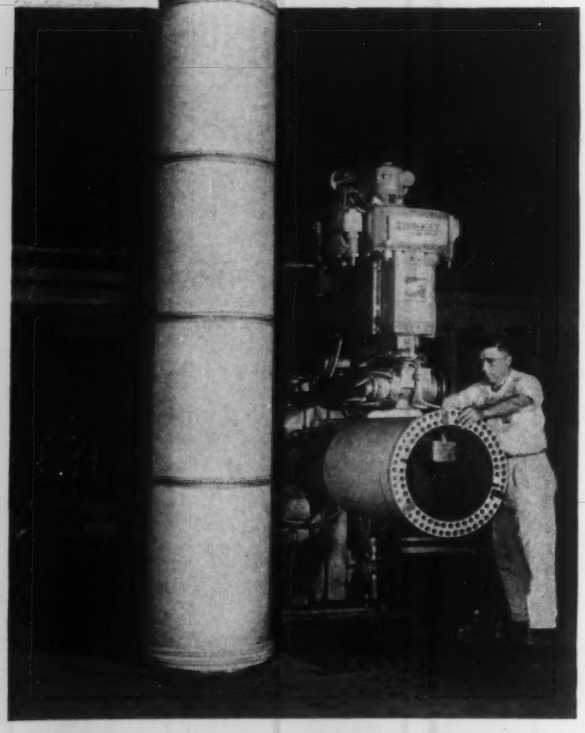
Circle 420 on page 19

HAYNES Alloys solve the *tough* heat problems

Searing 2,000 degree jet blast!



. . . Strong, Light-Gauge MULTIMET Alloy Saves 22% Tail Section Weight. One of the longest jet engine tailpipes made on a production basis is installed in the record-breaking A4D "Skyhawk" Navy attack bomber. The pipe is formed of 0.025-in. sheet.

The jet engine tailpipe of the Navy's A4D "Skyhawk" operates at extremely high temperatures. That is just one of the many reasons why this vital part is made of MULTIMET alloy.

This HAYNES alloy was selected for its high strength-to-weight ratio, as well as its exceptional performance at high temperatures. MULTIMET alloy provides greater resistance to burnout and erosion than any other material considered for this application.

Aircraft and other industries rely upon HAYNES alloys for use in after-burner components, turbine blades, jet engine tailpipes, nozzle vanes, cabin heaters, and a vast variety of other high-temperature applications.

For booklet or detailed information, write or phone any of the HAYNES STELLITE offices listed below. Address HAYNES STELLITE COMPANY, Division of Union Carbide Corporation, General Offices and Works, Kokomo, Indiana.

HAYNES ALLOYS

HAYNES STELLITE COMPANY

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the same firing method as the 20-mm, and mounting six rotating barrels from a central feed and firing housing.

Although it has three times the striking force of its 20-mm predecessor, the 30-mm gun has the same high rate of fire and approximately the same weight. It fires shells only 50 per cent larger than the earlier gun, but it inflicts far more damage. Both versions of the Vulcan can be electrically or hydraulically operated.

The 20-mm Vulcan is currently being used on the Air Force's Lockheed F-104 Starfighter.

Meetings

AND EXPOSITIONS

Sept. 9-11—

American Institute of Electrical Engineers. Petroleum Conference to be held at the Penn-Sheraton Hotel, Philadelphia. Further information can be obtained from AIEE headquarters, 33 W. 39th St., New York 18, N.Y.

Sept. 9-12—

Society of Automotive Engineers Inc. Tractor Meeting and Production Forum to be held at Hotel Schroeder, Milwaukee. Additional information is available from society headquarters, 485 Lexington Ave., New York 17, N.Y.

Sept. 9-13 —

Instrument Society of America. 12th Annual Instrument-Automation Conference and Exhibit to be held in the Public Auditorium, Cleveland. Further information can be obtained from Herbert S. Kindler, Director of Technical Programs, ISA, 313 Sixth Ave., Pittsburgh 22, Pa.

Sept. 17-20—

American Die Casting Institute. Annual Meeting to be held at the Edgewater Beach Hotel, Chicago. Additional information is available from institute headquarters, 366 Madison Ave., New York 17, N.Y.

Sept. 23-24—

Steel Founders' Society of America. Fall meeting to be held at The Homestead, Hot Springs, Va. Additional information can be obtained from society headquarters, 606 Terminal Tower, Cleveland 13, O.

Sept. 23-25—

American Society of Mechanical Engineers. Fall Meeting to be held at Hotel Statler, Hartford, Conn. Further information is available from ASME headquarters, 29 W. 39th St., New York 18, N.Y.

Sept. 23-25—

American Society of Mechanical Engineers. 12th Annual Conference of the Petroleum Div. to be held at Hotel Mayo, Tulsa, Okla. Further information is available from society headquarters, 29 W. 39th St., New York 18, N. Y.

Sept. 24-25—

Sixth Annual Industrial Electronics Symposium to be held at the Morrison Hotel, Chicago. Sponsors are the Institute of Radio Engineers and the American Institute of Electrical Engineers. Further information can be obtained from H. L. Garbarino, Armour Institute of Technology, 10 W. 35th St., Chicago 16, Ill.

Oct. 1-5—

Society of Automotive Engineers Inc. Aeronautic Meeting, Aircraft Production Forum and Aircraft Engineering Display to be held at the Ambassador Hotel, Los Angeles. Further information is available from SAE headquarters, 485 Lexington Ave., New York 17, N.Y.

Oct. 3-5—

Porcelain Enamel Institute. 26th Annual Meeting to be held at The Greenbrier, White Sulphur Springs, W. Va. Additional information is available from PEI headquarters, Associations Bldg., 1145 Nineteenth St. N.W., Washington 6, D. C.

Oct. 7-9—

American Society of Lubrication Engineers — American Society of

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Circle 422 on page 19

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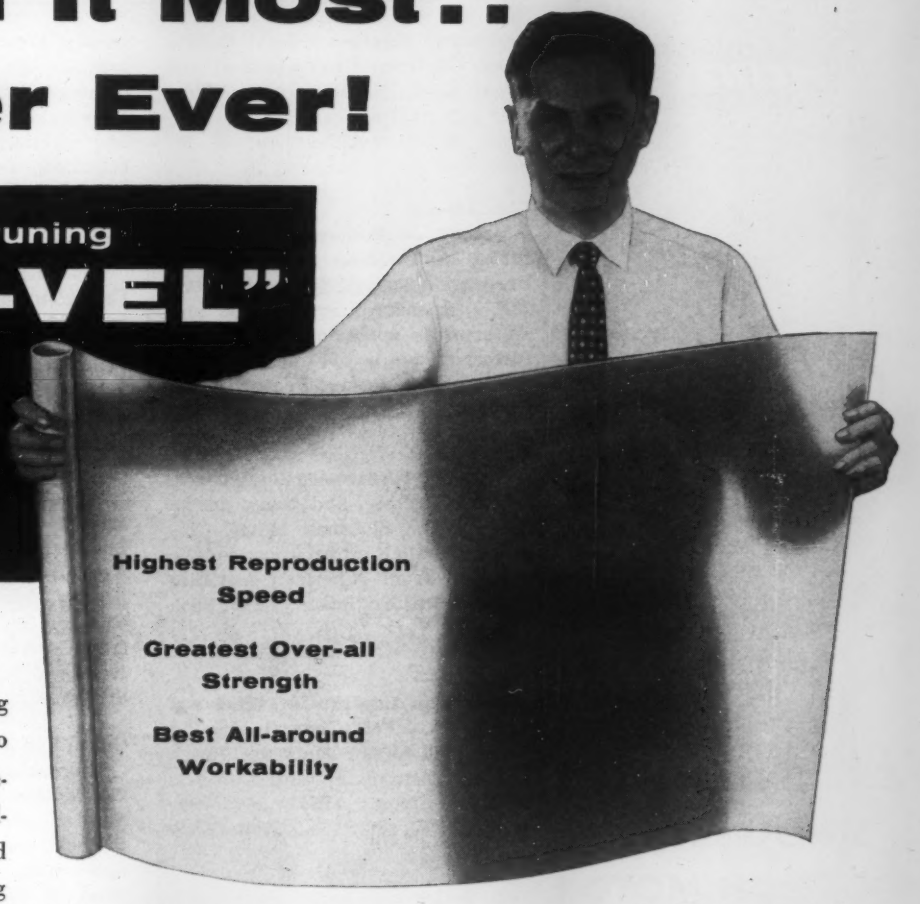

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Circle 423 on page 19

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New in design, new in economy — the Heinze P Motor answers your need for a low-cost single coil 2 pole induction motor. It is available in various stacks and horsepower ratings from 1/300 to 1/50. Free speed is 3400 rpm; load speed 3000 rpm. Designed for 115 V, 60 cycle operation, the Heinze P Motor has broad application — in movie projectors, fans, gearmotors, advertising displays, pumps, toys, etc.

You have a wide choice of models from the comprehensive line of Heinze sub-fractional horsepower motors and blowers. Heinze Engineers are also ready to adapt standard models — or design a complete new motor or blower for your exact needs. Send us your product and specifications. We'll adapt a motor . . . at no obligation. Write for catalog.

HEINZE ELECTRIC COMPANY
685 Lawrence St., Lowell, Mass.

Sub-fractional Horsepower Motors and Blowers

Circle 424 on page 19

Engineering News Roundup

Mechanical Engineers Joint Lubrication Conference to be held at the Royal York Hotel, Toronto. Further information can be obtained from ASLE headquarters, 84 E. Randolph St., Chicago 1, Ill.

Oct. 7-9—

Second Conference on Manufacturing Automation to be held at Purdue University, West Lafayette, Ind. Sponsoros are Purdue and *Automation* magazine. Further information can be obtained from the Editor, *Automation,* Penton Bldg., Cleveland 13, O.

Oct. 7-9—

National Electronics Conference. Annual Meeting and Show to be held at the Sherman Hotel, Chicago. Further information can be obtained from American Institute of Electrical Engineers, 33 W. 39th St., New York 18, N.Y.

Oct. 7-11—

American Institute of Electrical Engineers. Fall General Meeting to be held at the Morrison Hotel, Chicago. Additional information is available from AIEE headquarters, 33 W. 39th St., New York 18, N.Y.

Oct. 9-11—

Gray Iron Founders' Society Inc. Annual Meeting to be held at the Drake Hotel, Chicago. Further information can be obtained from sosiety headquarters, National City -E. Sixth Bldg., Cleveland 14, O.

Oct. 14-15—

Fourth Conference on Mechanisms to be held at Purdue University, West Lafayette, Ind. Sponsors are the Purdue School of Mechanical Engineering and MACHINE DESIGN. Additional information can be obtained from the Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, O.

"Why can't you go on vacation like everyone else?"

Oct. 16-18—

Institute of Radio Engineers. Canadian Convention-Exposition to be held in the Automotive Bldg., Exhibition Park, Toronto. Further information can be obtained from IRE headquarters, 1 E. 79th St., New York 21, N. Y.

Oct. 17-18—

National Conference on Industrial Hydraulics to be held at Hotel Sherman, Chicago. Sponsors are Armour Research Foundation and Illinois Institute of Technology. Further information is available from Conference Secretary, Armour Research Foundation, 10 W. 35th St., Chicago 16, Ill.

Oct. 17-18—

Magnesium Association. Annual Convention to be held at the Biltmore Hotel, New York. Additional information can be obtained from association headquarters, 122 E. 42nd St., New York 17, N. Y.

Oct. 17-19—

Foundry Equipment Manufacturers Association Inc. Annual Meeting to be held at the Greenbrier, White Sulphur Springs, W. Va. Further information is available from association headquarters, 1 Thomas Circle, Washington 5, D. C.

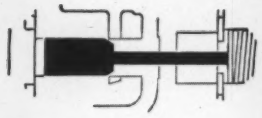
Oct. 23-25—

National Fluid Power Association. Fall Meeting to be held at Hotel Statler, Washington, D. C. Additional information can be obtained from association headquarters, 1618 Orrington Ave., Evanston, Ill.

Oct. 27-30—

American Gear Manufacturers Association. Fall meeting to be held at the Edgewater Beach Hotel, Chicago. Further information is available from AGMA headquarters, 1 Thomas Circle, Washington 5, D. C.

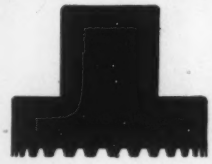
Here's a liftable idea for you in



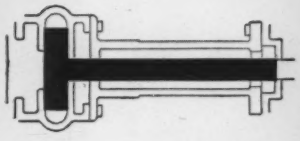
Piston for hydraulic control valve

One-piece bevel gear and shaft

LARGE-HEAD STEEL FORGINGS



Spline-toothed coupling and shaft



Integral pump gear and shaft

A one-piece steel forging is probably the cost-reducing answer to many a part you now make by assembling a shaft to a thick disk or by costly machining from expensive bar stock. Above are sketched some ideas of uses for large-head steel forgings made by the Valve Division.

Advantages of one-piece extruded forgings over your present two-piece assemblies include:

Elimination of fitting and assembly,
Continuous grain structure around neck,
Only one part to machine,
Reduction in costly machining,
Elimination of costly scrap generation,
Improved structural strength,
No loosening of head on shaft.

Interested? Then let us send a Valve Division engineer to discuss the mechanics and economics of switching to large-head forgings. They are made in the same Valve Division plant that has produced over 1 billion large-head forgings as engine valves for all leading truck, automobile, aircraft, and industrial-engine builders. Write to Department MD-157 at the address below.

Valve Division ***Thompson Products, Inc.***

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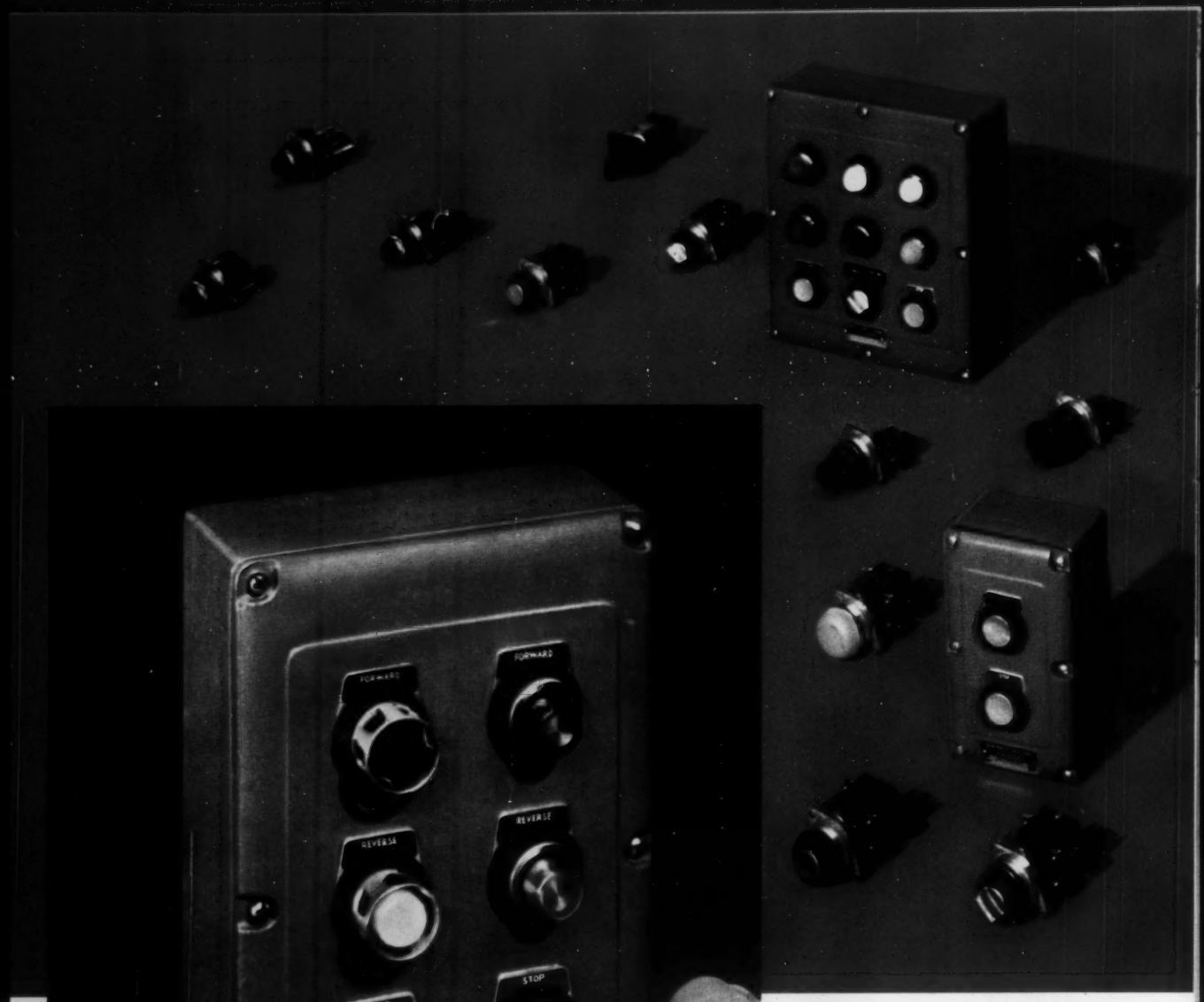
Circle 425 on page 19

Circle 426 on page 19→



ILLUMINATED
PUSH BUTTON

PUSH TO TEST
INDICATING LIGHT

OIL-TIGHT PUSHBUTTON LINE

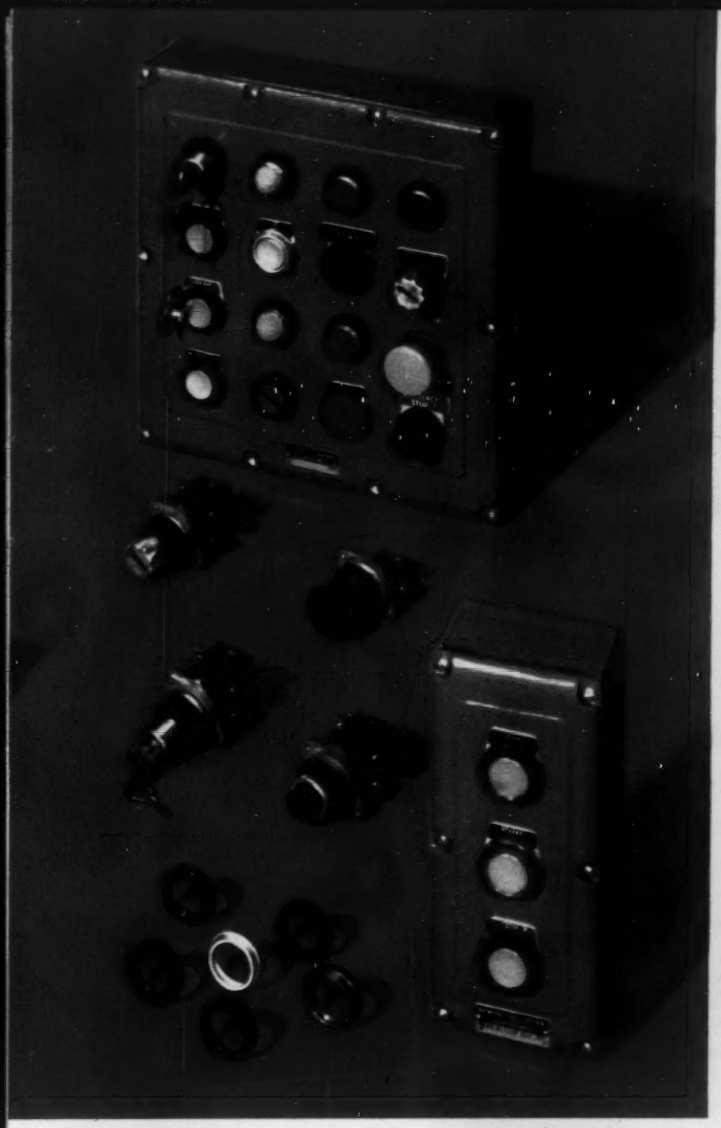
General Electric's oil-tight line includes: standard and mushroom-head buttons; selector switches and potentiometers; indicating lights in six colors; and other special operators. Stations are available to accommodate one to sixteen units.

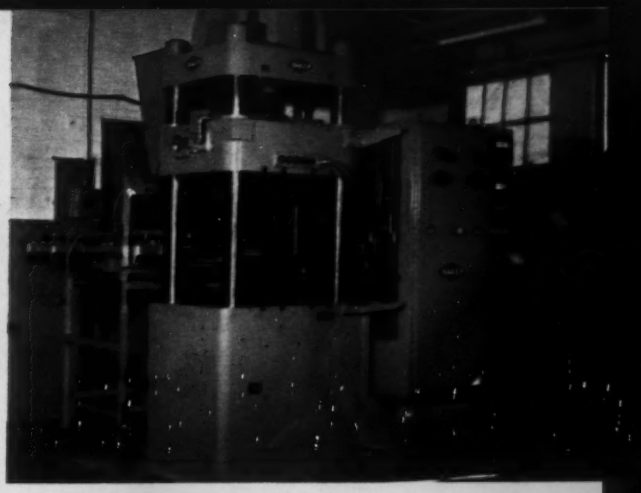
ILLUMINATED PUSH BUTTON

Color caps are available in red, green, amber, white, blue and clear. Units can be furnished with guard (left on station). Transformers are available rated 110, 220 volts, 50/60 cycle or 440 volts, 60 cycle.

PUSH TO TEST INDICATING LIGHT

Faceted lens provides greater dispersion of light and gives all-angle visibility. Forms are available with the same transformer ratings and with the same six lens colors as the illuminated button.





BAKER BROTHERS, INC., Toledo, Ohio, has standardized on General Electric oil-tight push buttons for their plastic molding presses. Units are front mounted on control panel door.

ONSRUD SPAR MILLING MACHINE—operated by G-E oil-tight push buttons in flush panels and a pendant station—is made by Onsrud Machine Works, Inc., Chicago, Illinois.

ADDED TO GENERAL ELECTRIC'S OIL-TIGHT PUSH BUTTON LINE, A...

NEW illuminated push button and a NEW push to test indicating light

A new space saving illuminated push button and a quick-check, push to test indicating light have been added to the General Electric oil-tight pushbutton line. The illuminated push button is a single unit that provides the functions of both a push button and an indicating light, and can save you half your mounting area. The new push to test unit meets the newly revised JIC standards for push-to-test indicating lights. Both new units fit the same mounting hole and space as other units in the line.

BOTH NEW UNITS are furnished with one standard contact block, and a permafil encapsulated transformer with the bulb mounted on the front. The encapsulating material helps insulate the transformer windings, and provides additional strength and resistance to mechanical damage. The bulb is the new plug-in G-E No. 12, 6 volt lamp, which has extremely long life.

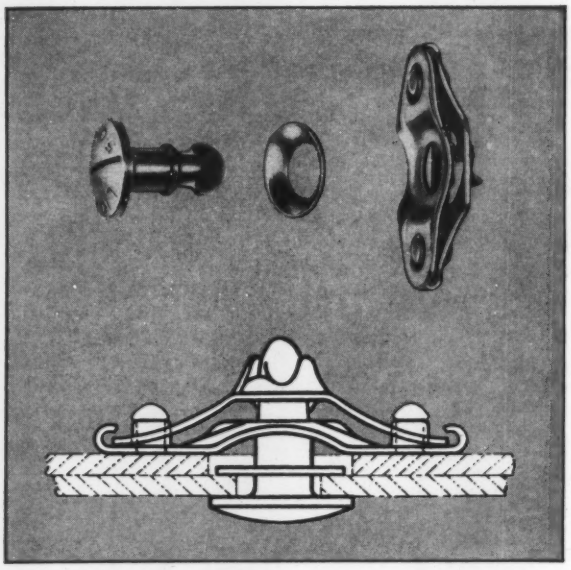
FLEXIBILITY in selection is one important feature of the entire General Electric oil-tight pushbutton line. Building-block construction allows you to use the same contact block with all separable operators, color rings and nameplates. Indicating lights, special units and accessories complete the line to give the many combinations you need.

FOR DETAILS of the new units and the complete oil-tight line, see your nearest General Electric Apparatus Sales Office or Distributor. Or, write for bulletin GEA-5779, Advertising Section 731-12, General Electric Co., Bloomington, Illinois.

GENERAL ELECTRIC

One-quarter turn . . .
CLOSED

One-quarter turn . . .
OPEN



LION QUARTER-TURN FASTENERS

QUICK TO INSTALL

Lion Fasteners can be installed rapidly. Studs simply slip through drilled hole and are retained by a grommet. Springs are riveted or spot-welded in place.

RUGGED

Lion Fasteners stand up under the most rugged conditions of shear, tension, and vibration . . . meet or exceed the exacting requirements of Army-Navy-Air Force Specifications MIL-F-5591A (ASG) and have Civil Aeronautics Administration approval for civilian aircraft use.

LIGHTWEIGHT

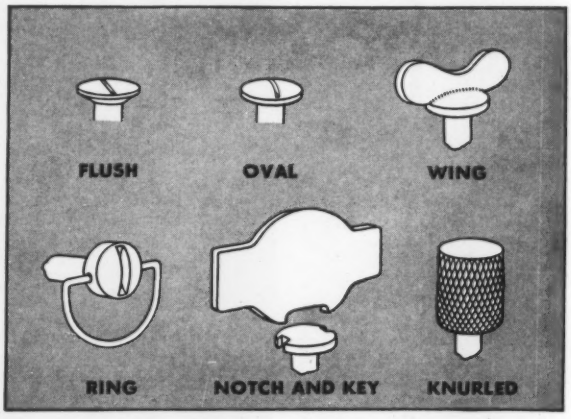
Made of cadmium-plated steel to provide a high strength-low weight ratio, No. 5 Fasteners weigh only 12 to 14 lbs. per 1000 . . . No. 2 Fasteners 3¾ lbs. per 1000 . . . No. H Fasteners approximately 35 lbs. per 1000.

VIBRATION-PROOF

This group of fasteners is particularly suited to metal fastening conditions where vibration is an important factor. Lion Fasteners can't shake loose . . . can't open by themselves.

FULL RANGE OF HEADS...

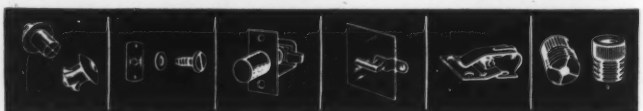
The Lion No. 5 Fastener is available with flush, oval, ring, wing, knurled, or notched head and key; No. 2 Fastener is available with flush, oval, or wing type head; the No. H Fastener comes with an oval head.



LION Quarter-Turn FASTENERS

SOUTHCO FASTENERS
LION

For complete information on Lion Quarter-Turn Fasteners, as well as on the complete Southco line, write today to Southco Division, South Chester Corporation, 237 Industrial Highway, Lester, Pa.



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Circle 427 on page 19

(Advertisement)

DESIGNING WITH ALUMINUM

This is one of a series of information sheets which discuss the properties of aluminum and its alloys with relation to design. Extra or missing copies of the series supplied on request. Address: Advertising Dept., Kaiser Aluminum & Chemical Sales, Inc., 1924 Broadway, Oakland 12, California.

NO. 25

ADVANTAGES OF ALUMINIZED STEEL

ALUMINUM COATINGS on steel provide a means for combatting corrosion and oxidation problems which cost consumers billions of dollars each year. For unless steel is protected by coating, painting or alloying, it deteriorates rapidly in the presence of moisture or high temperatures.

A coating material for protecting steel should have three virtues: long life which means low maintenance, good appearance and usefulness in a variety of environments. Aluminum coatings meet these requirements at low cost.

Favorable Cost Comparison

The cost of aluminized steel is dependent on the cost of the coating metal, the cost of applying the coating and the price of steel. If aluminized steel is compared to zinc-coated (galvanized) steel and the price of steel is assumed to be the same for either coating, then the fact that aluminum is only about one-third as dense as zinc makes the cost of aluminum less than that of zinc for equal thicknesses of coating.

This favorable material cost for aluminum may be somewhat decreased by slightly higher costs of applying aluminum to steel, although fixing the production costs is difficult. Much depends on the process used and the experience of the operator. In general, aluminizing and galvanizing by hot-dipping, which is the most economical process, are comparable and competitive in cost.

Unique Advantages of Aluminum

Aluminum coatings offer advantages in performance and sales appeal in a wide field of applications. On steel they impart the inherent corrosion resistance of aluminum to the steel surface. When suitably treated, aluminized steels are resistant to oxidation at temperatures up to 1800°F.

Aluminum gains its resistance to corrosion at lower temperatures from a thin, colorless layer of oxide which forms rapidly on its surface. Even if the oxide surface layer is scratched, "self-healing" occurs through rapid reoxidation of the affected area.

In very corrosive environments, the aluminum may be attacked slightly, but the attack soon stops because of the protection given by the corrosion products themselves. Zinc, on the other hand, forms corrosion products which are soluble in water, particularly in sulfurous industrial atmospheres. Hence, the protection is gradually lost by dissolution of zinc and through galvanic action as zinc is anodically sacrificed for iron.

Aluminum coatings are also anodic to steel in the presence of electrolytes. However, their electrochemical reaction rates under these conditions are not as rapid as the reactions of zinc.

diffused into the steel at 1500-1700°F, the surface of the steel is sufficiently alloyed to prevent oxidation. These coatings are known as "calorized" coatings.

Table II summarized the performance of aluminized steel and mild steel at a temperature of 1300°F. At temperatures up to 900°F, well above the melting point of zinc, aluminized coatings will not discolor in normal use.

CORROSION RESISTANCE OF HOT DIP ALUMINUM COATED AND ZINC COATED STEELS IN NATURAL ENVIRONMENTS

Atmospheres	Product	Period of Exposure	Comparative Appearance
(Severe marine)	Flat Sheet	4½ years	Aluminized steel surface remains relatively bright. Surface of galvanized steel is dull gray. Rust on both materials observed at sheared edges only.
(Severe marine)	Core wire in #4 AWG 6/1 ACSR	4 years	Aluminized steel core wire better than Grade C heavy zinc coated steel wire and markedly superior to Grade A standard zinc coated steel core wire.
(Severe marine)	Poleline Hardware (cross arm braces, insulator pins and racks, threaded ware)	1 year	Aluminized steel hardware excellent condition, surface bright with only slight tarnish. Galvanized steel hardware covered with heavy white deposits and numerous rust spots.
(Severe industrial)	Flat Sheet	1 year	Aluminized steel dark gray with traces of rust at sheared edges only. Galvanized steel covered with rust over more than 50% of surface.
(Industrial)	Flat Sheet	2½ years	Aluminized steel and galvanized steel comparable in appearance. Surfaces dulled with soil deposits. Traces of rust at sheared edges.
(Urban)	Flat Sheet	4 years	Aluminized steel and galvanized steel comparable in appearance. Surfaces dulled gray with soot and dirt deposits. Traces of rust at sheared edges.
	Fence Wire & Barbed Wire	2 years	Aluminized steel remains brighter than galvanized steel. Rust traces at sheared ends of wire where steel exposed.

TABLE I

Occasionally, a slight discoloration may occur at sheared edges and discontinuities in the coating on aluminized steel, but the attack is not progressive and soon halts. In many cases the rust stains will later vanish. Table I shows the results of some recent atmospheric corrosion tests on aluminized and galvanized steels.

Excellent Heat Resistance

The heat resistance of aluminized steel has been known for years. When steel contains aluminum in amount exceeding about 9%, the alloy becomes extremely resistant to scaling at high temperatures. If an aluminum coating is

The heat reflectivity of aluminized steel is excellent. At temperatures up to 900°F, about 80% of the radiant heat

RESULTS OF OXIDATION TESTS AT 1300°F

MATERIAL	Increase in weight in mg/cm² at 1300°F after: 100 HRS.	1000 HRS.
Mild Steel	40.4	147.7
Aluminum Coatings		
Sprayed and heat treated	0.96	3.37
Sprayed, no heat treatment	6.68	13.8
Hot dipped	0.73	2.2
Comm. Aluminum	0.80	3.81
Hot dip 2.65% Si Alloy	1.2	6.2

TABLE II

CONTINUED ON NEXT PAGE ➡

Circle 428 on page 19

is reflected by the aluminum coating. By lightly rolling aluminized sheet or strip, the surface attains the appearance of rolled aluminum with resulting high reflectivity.

Since aluminum is an excellent conductor of heat, the thermal conductivity of aluminized steel is considerably better than that of uncoated steel and alloy steel.

Wide Range of Applications

Aluminized steel can be welded and brazed, drawn and formed, painted and porcelain enameled. It can also be soldered by special techniques. This versatility of aluminized steel makes it attractive for many applications.

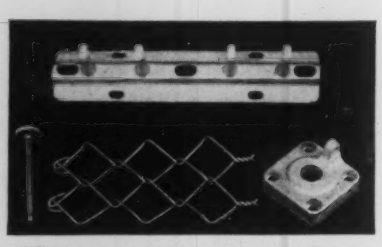

FIGURE 1 Examples of Aluminized Steel Products

A few of the products made of aluminized steel are shown here. Included are a steel forging, cast iron part, fence wire, and an automotive valve on which the head and seat only were aluminized. This valve is an excellent example of how the heat resistance of aluminized coatings can be used effectively. Sheet products are also available and are used in outdoor barbecues, dry kiln fan walls and doors, oil and gas floor-furnace combustion chambers and casings, baking pans, automotive mufflers, and many other applications.

A potentially large consumer of aluminized steel is the electrical transmission and distribution industry where aluminized pole line hardware, telephone wire, and ACSR core wire offer substantial advantages.

For example, in a test involving a severe marine environment, aluminized steel pole line hardware showed no sign of failure after ten months exposure while zinc-coated counterparts were virtually covered with rust.

It is difficult to express the "life" of aluminized steel in terms of the life of galvanized steel, because test samples have not yet failed even though similar zinc-coated items have been destroyed by corrosion in the same environment and in the same exposure period.

Aluminized steel has the pleasing appearance of aluminum but its strength-weight ratio is lower than that of the solid aluminum alloys.

Selection of Coating Alloy

An aluminum coating alloy should be selected with a view to the application of the product. After years of study, Kaiser Aluminum's Department of Metallurgical Research has developed aluminizing alloys with excellent appearance, corrosion resistance, ductility.*

The addition of certain elements alters the melting and solidification characteristics of aluminum coatings and inhibits the diffusion between iron and molten aluminum. This results in smooth surface textures, bright luster and good bending properties. The functions of some of the alloying elements are shown in Table III.

FUNCTIONS OF ALLOYING ELEMENTS IN ALUMINIZED COATINGS[1]

Silicon	— inhibits diffusion between iron and aluminum, thus increasing coating ductility; increases bath fluidity.
Iron, Chromium, Titanium, Boron, Zinc, Beryllium	— improve appearance by increasing coating luster, producing silvery color and smooth surface texture.
Sodium	— increases bath wettability.

[1]All of the alloying elements are not necessarily used in a single coating alloy.

TABLE III

The alloying elements cannot be added indiscriminately. For example, the iron-aluminum alloy layer shown in Figures 2 and 3 should be as thin as possible for the best ductility, less than 0.0004" thick in coatings of 0.001" total thickness. Silicon, by inhibiting the diffusion between iron and aluminum, prevents excessive growth of the brittle iron-aluminum layer. However, coating alloys containing more than 3% silicon darken rapidly and although their corrosion resistance is excellent, they develop an inferior appearance.

*As covered by patent rights of Kaiser Aluminum & Chemical Corporation.

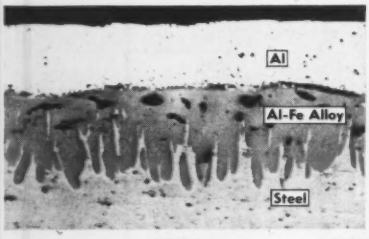

FIGURE 2 500X
Microstructure of Non-ductile Aluminized Coating Obtained with Commercially Pure Aluminum Coating Alloy.

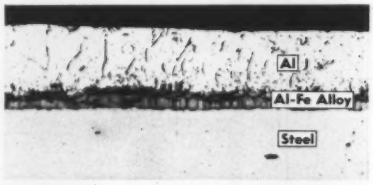

FIGURE 3 500X
Microstructure of Ductile Aluminized Coating Obtained with Kaiser Aluminum Coating Alloy Containing Silicon and Other Alloying Elements.

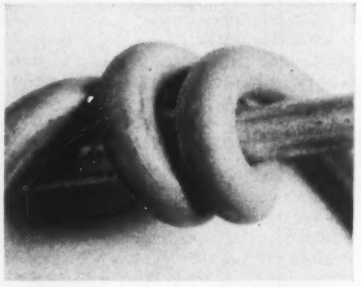

FIGURE 4 3X
Wrap Test on Aluminized Wire with Ductile Coating.

Excessive amounts of iron, chromium, titanium and boron produce rough surface textures, which may adversely affect coating ductility as well as appearance. Thus, a careful balance of alloying element concentration is necessary to obtain optimum properties.

Future of Aluminized Steel

Aluminized steel products are appearing on the market in increasing numbers and applications. The superior performance, appearance, and adaptability of aluminized coatings in various environments are leading progressive designers and sales conscious manufacturers to make use of these advantages.

For information and assistance concerning aluminizing alloys and processes, contact the Kaiser Aluminum sales office or distributor listed in your telephone directory. Kaiser Aluminum & Chemical Sales, Inc., *General Sales Office*, Palmolive Bldg., Chicago 11.

see our catalog in
PRODUCT DESIGN FILE
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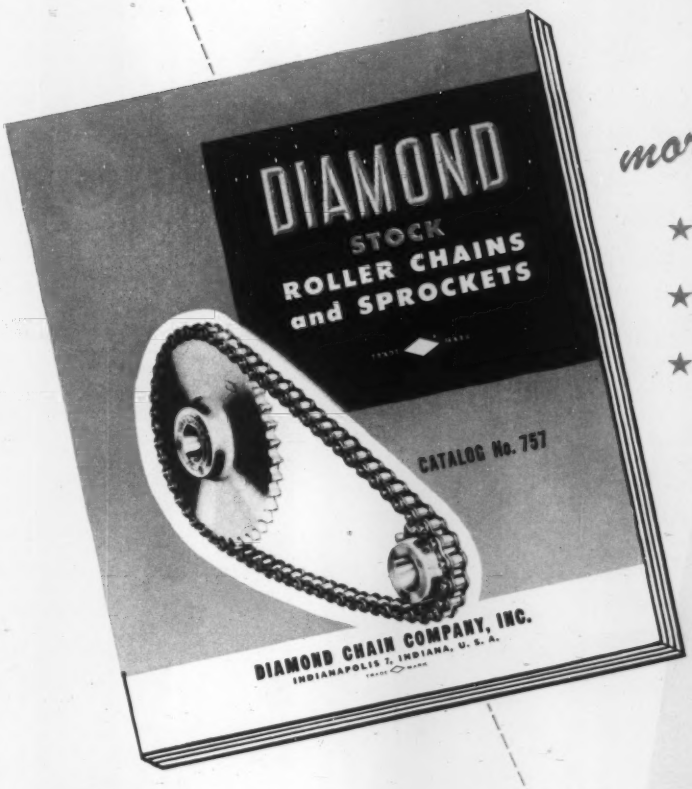

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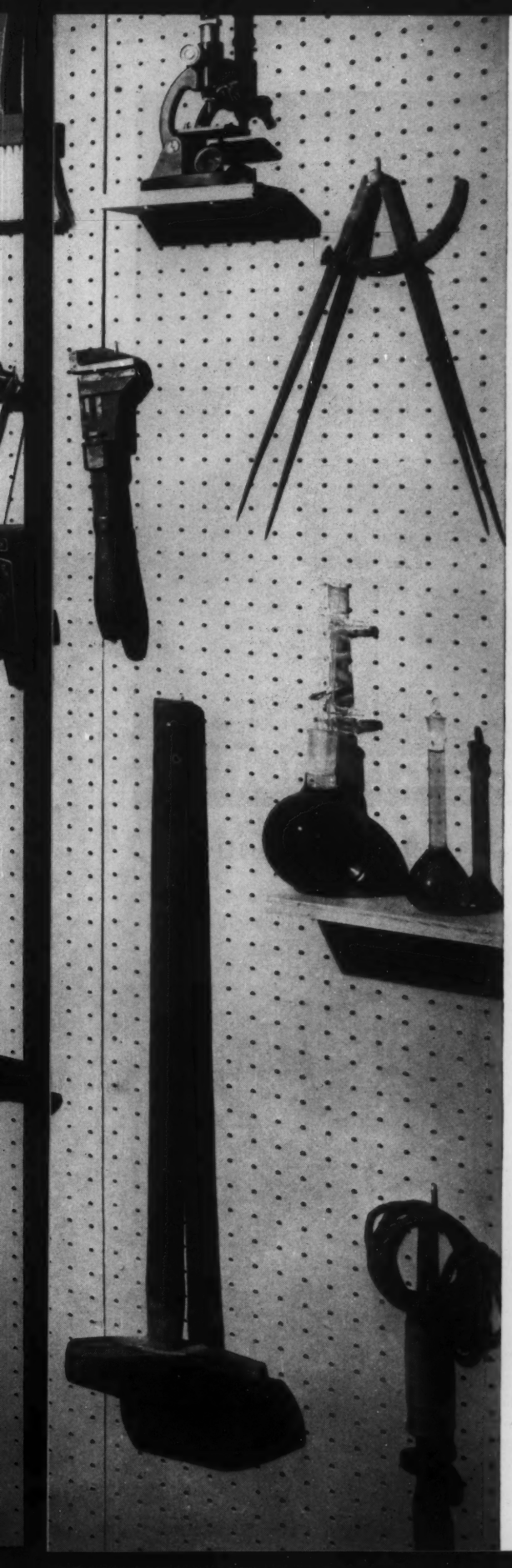

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IT'S SAD BUT TRUE that the product design engineer of today has to be a many-faceted expert. He has to be an engineer *and* a materials expert *and* a production expert. He has to be well up on purchasing fundamentals, plus the elements of cost accounting.

There is one design responsibility from which we can give you some relief, though. That is the selection of springs. Spring design is a field unto itself, and, although we'll be glad to give you mountains of interesting information on the subject, why concern yourself with it? We'll do the work for you.

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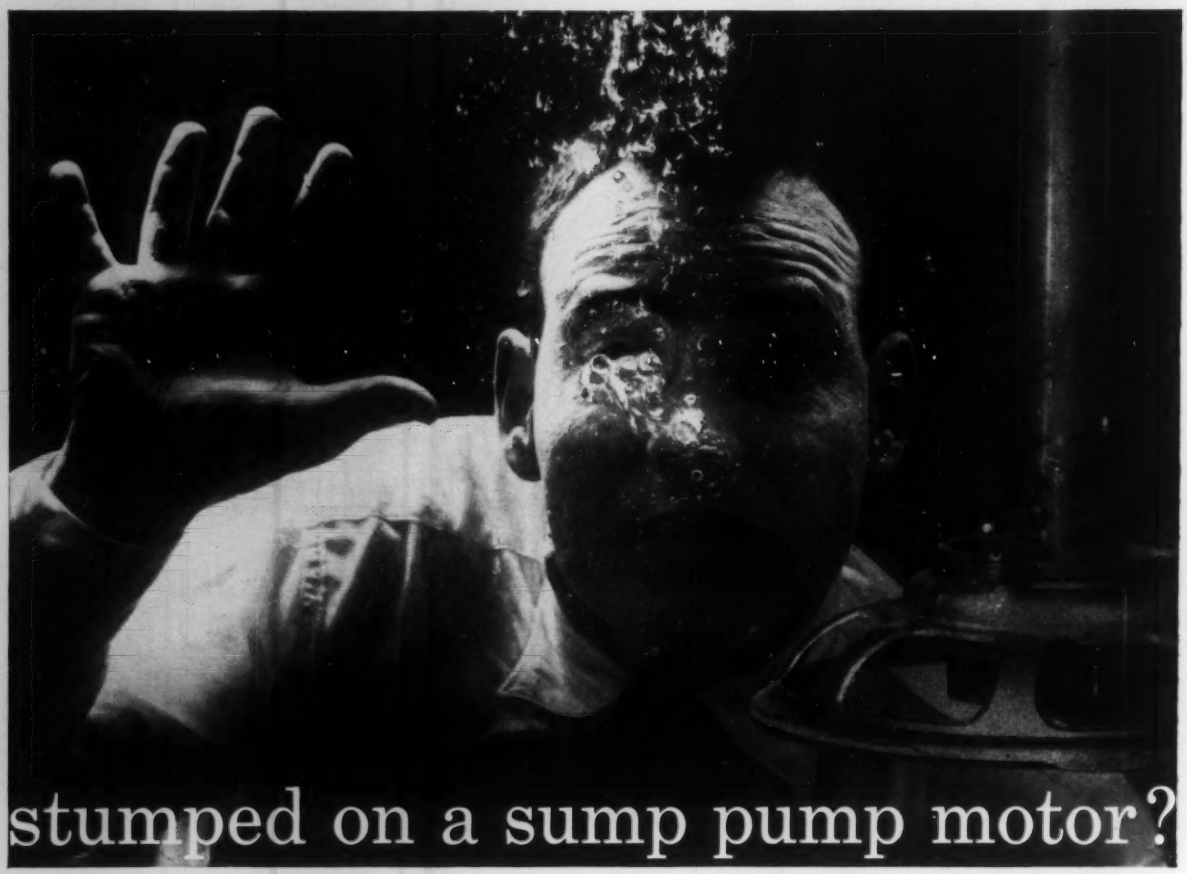

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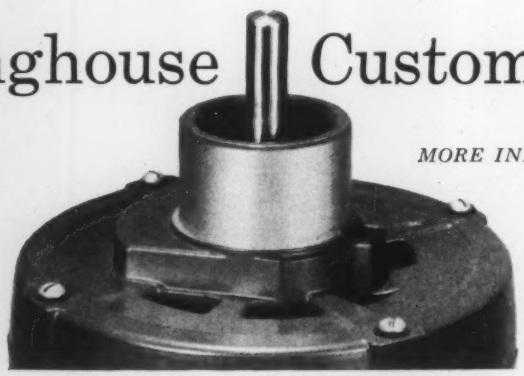

MORE INFORMATION?

Just call your nearest Westinghouse sales engineer or write to Westinghouse Electric Corporation, Small Motor Division, Lima, Ohio.

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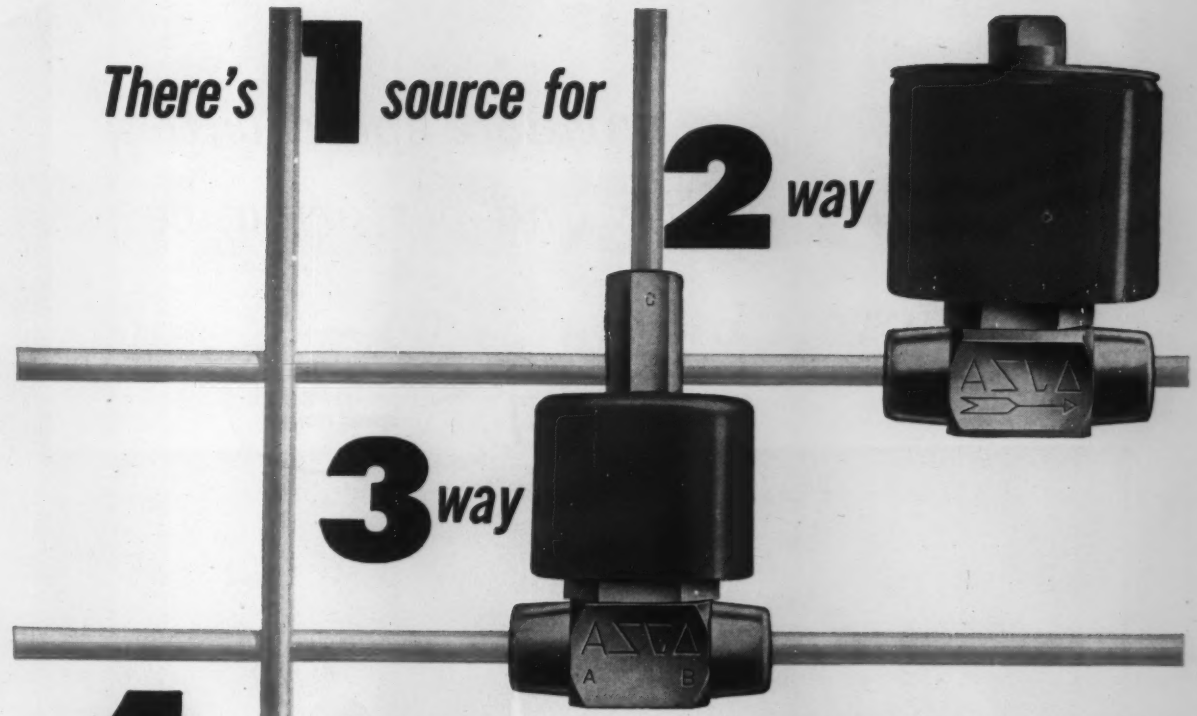
There's 1 source for 2 way 3 way or 4 way MIDGET SOLENOID VALVES



Progressive designers, the men who lead the trend toward miniaturization, depend on ASCO as the one source for a full line of midget solenoid valves. The unexcelled quality and dependability that ASCO pioneered in the solenoid valve field is found, too, in today's midget solenoid valves. Only the size has been reduced.

For flow applications using air, gas, water, light oil, refrigerants and many other liquids, ASCO Midget Valves assure complete safety and truly exceptional performance.

ASCO Midget Solenoid Valves are available with standard, watertight or explosion-proof enclosures. Pipe sizes ⅛" and ¼"; pressure range 0-1000 psi.

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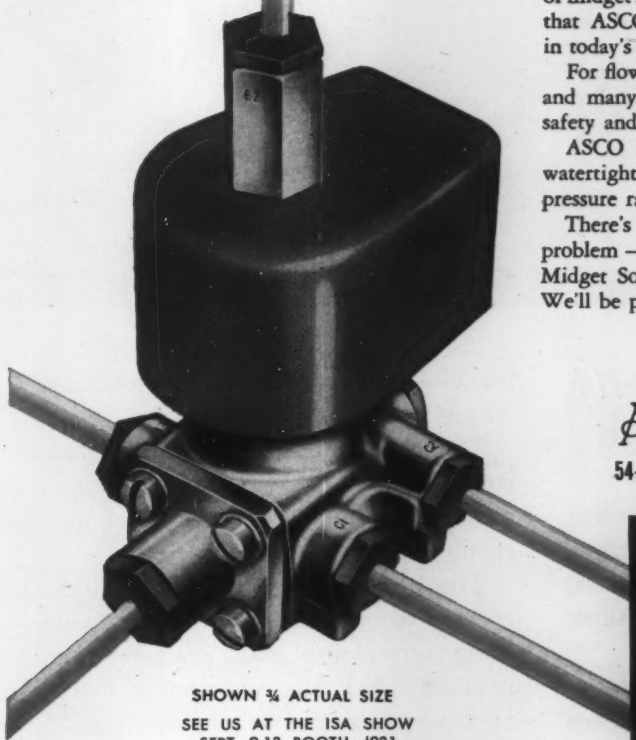

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The flexible design permits hundreds of combinations . . . space-saving, space-fitting *standard* assemblies to meet most installation requirements.

The handwheel control location can be rotated to optional positions for greater operating convenience; extra precision of control is available with the addition of one or more REEVES accessories or modifications.

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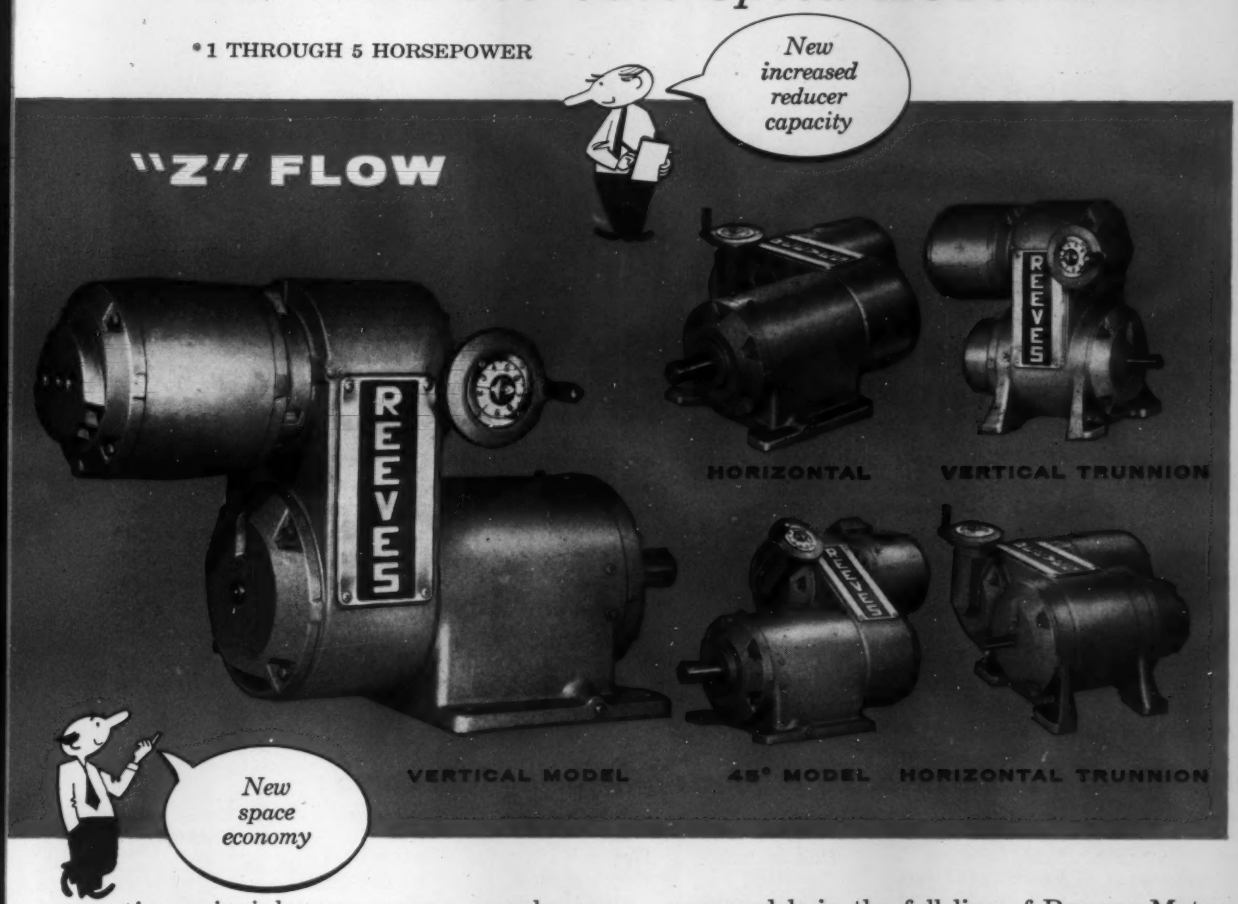

operating principle now assure even longer trouble-free service.

New disc assemblies permit wider output speed ranges . . . discs are pre-aligned . . . pre-loaded spring maintains correct belt tension for longer belt wear . . . *exclusive* "close-grooving" lubrication assures free sliding discs . . . new Metermatic system automatically lubricates the motor and variable shaft bearings.

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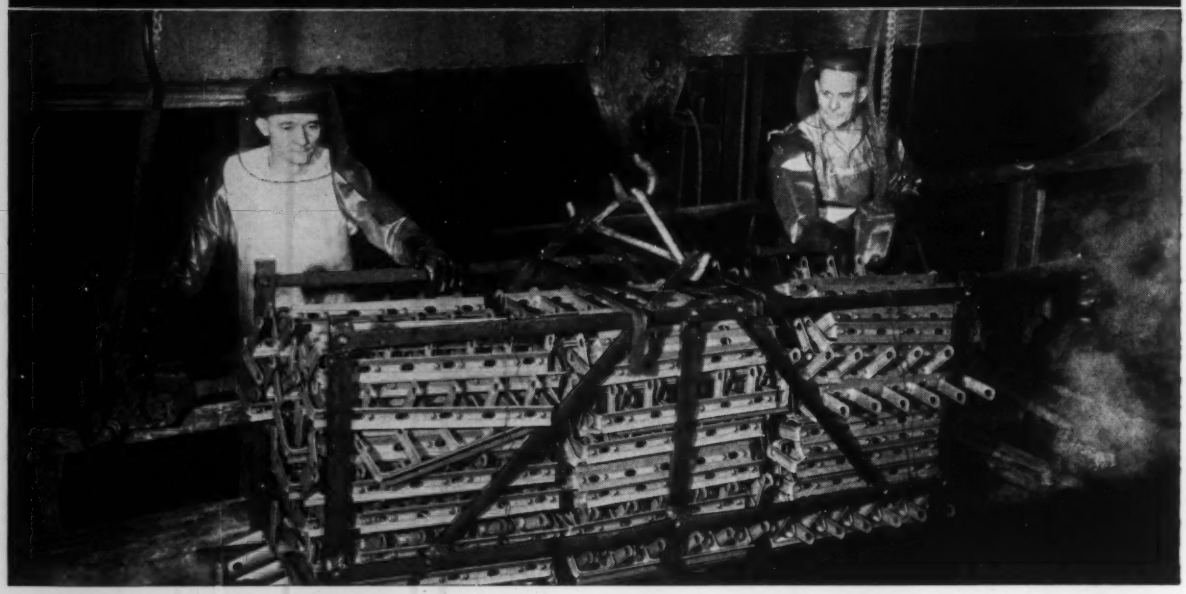
REEVES PULLEY COMPANY

Division of **RELIANCE** ELECTRIC AND ENGINEERING CO.

Columbus, Indiana

Circle 434 on page 19

How's this for corrosion control?



Carpenter Stainless No. 20 pickling rack still in H_2SO_4 service after 5½ years!

Steady exposure to 5-15% sulphuric acid at temperatures up to 200°F for over 5½ years is the service record of this pickling rack made from Carpenter Stainless No. 20. It supports heavy loads of pole line hardware during pickling. Dependable corrosion resistance in the steel is invaluable.

Ordinary steels lasted but a short time on this application. Then, Carpenter Stainless No. 20 was put to work. The result is added safety for the workers, substantial savings in replacements, and uninterrupted production.

Today industry is finding a host of uses for this super corrosion-resisting steel. A wide variety of products of No. 20 can be purchased already fabricated . . . or you can build your own. In addition to hot sulphuric acid, this unique steel resists attack by a long list of other corrosives.

Whatever your corrosive application, talk to Carpenter first about the cost-saving advantages of No. 20. Over 70 years' experience in the development and manufacture of specialty steels are at your service when you contact your nearest Carpenter Mill-Branch Warehouse, Office or Distributor.

Partial list of Stainless No. 20 products now being fabricated:

- Agitating equipment
- Baskets
- Centrifugal pumps and parts
- Coils
  - Heating and cooling
- Dehydrators
- Exchangers, Heat
- Fans
- Fastenings (all types of standard and special design)
- Fittings
- Grommets
- Hangers
- Instruments
  - Heat and temperature
  - Industrial liquid level
- Mixers
- Nozzles
- Pails for sulphuric acid
- Pipe
- Processing equipment (food and chemical industry)
- Pump parts
- Screws
- Tanks, welded
- Thermocouple wells
- Tube
- Valve parts
- Valves
- Vessels, welded
- Weld rods
- Wire
  - Baskets
  - Cloth
  - Stranded
- And others

Carpenter Stainless No. 20-Cb is available from The Carpenter Steel Company, Alloy Tube Division, Union, New Jersey, in the forms of tubing, sheet, strip, pipe and plate; and Stainless No. 20 in the forms of bars, billets and wire.

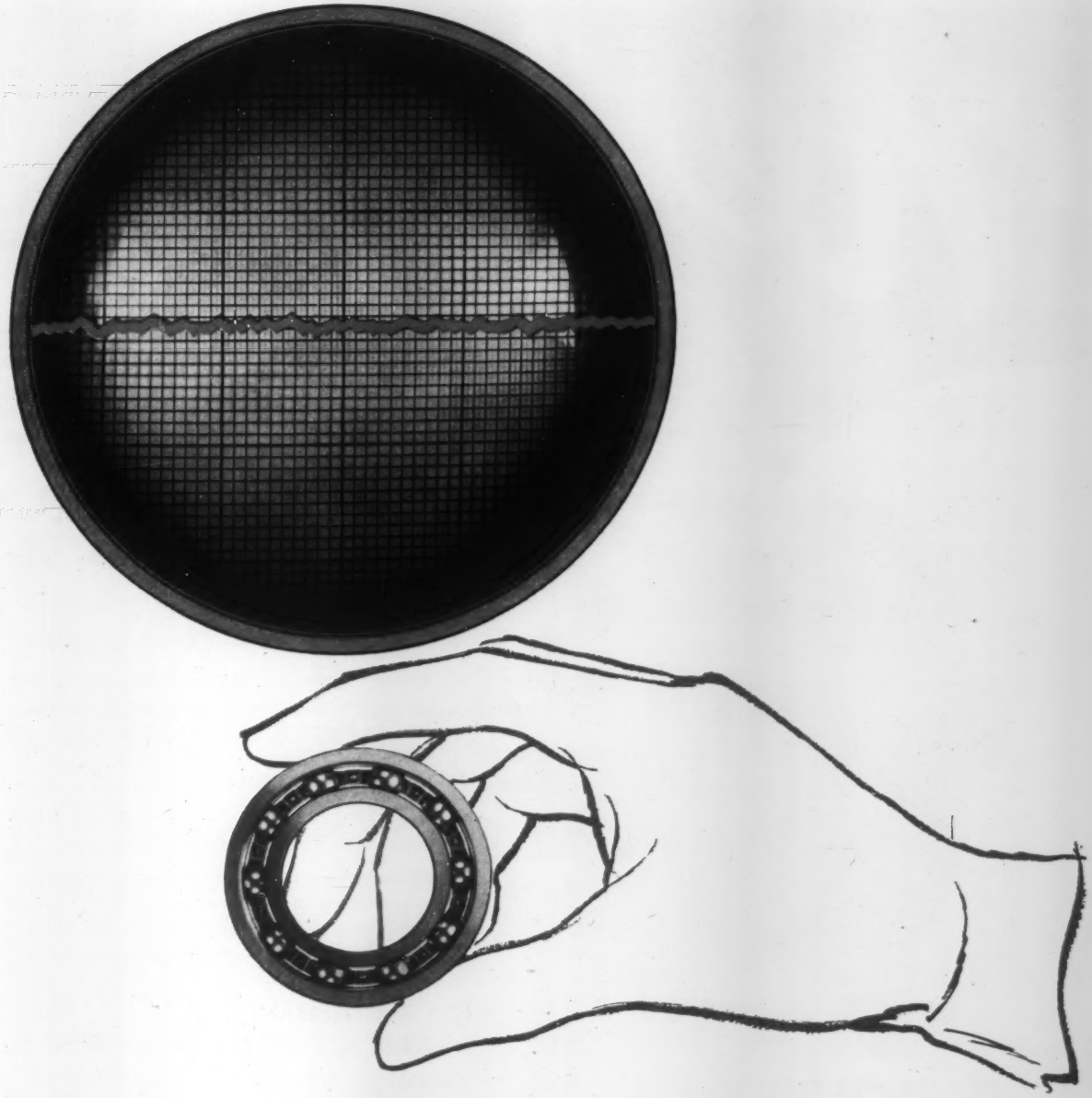
Our new leaflet *"Positive Protection"* has a more complete list of available products made from No. 20. If you haven't a copy, please drop us a line.

Carpenter STEEL

Super Corrosion-Resistant Stainless

Pioneering in Improved Tool, Alloy and Stainless Steels Through Continuing Research

The Carpenter Steel Co., 120 W. Bern St., Reading, Pa.
Export Department: The Carpenter Steel Co., Port Washington, N. Y.—"CARSTEELCO"



SCIENTIFIC "SOUNDINGS" PRODUCE QUIET BEARINGS

Through the application of the latest electronic instruments, SKF research engineers have been able to further reduce the sound factor in anti-friction bearings. SKF provides the quietest running, rolling contact bearing in the world of today... at no added cost.

Other recent laboratory achievements include improvements in sealing and increase in bearing operating life, further assuring users the best bearings for their dollar. But accept no substitutes — you benefit from these only when you insist upon SKF. 7763

SKF®

EVERY TYPE—EVERY USE

Spherical, Cylindrical, Ball, and Tyson® Tapered Roller Bearings

*Reg. U.S. Pat. Off. Tyson Bearing Company

SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.

Circle 436 on page 19

New line STEARNS

Save up to
Save up to
Torque range - 9 to 540 lb ft

Patent Pending

NEW SIMPLICITY — COMPACTNESS

Direct magnetic action eliminates mechanical yokes, shifters, self-energizing actions. Plug-in electrical connections eliminate slip rings or brushes. Rugged, compact, fully tested, foolproof design.

FAST — SIMPLE INSTALLATION

The stationary magnet body can be anchored against rotation with a simple strap assembly. All clamping forces are self-contained — eliminate thrust loads on shafts or machine elements.

LOW MAINTENANCE — QUICK, POSITIVE ADJUSTMENT

"A screwdriver is your tool kit." Long-life friction linings seldom need adjustment for wear—quickly accomplished by turning three screws. Sealed, prelubricated, oversize bearings provide extra capacity — never need additional lubrication under normal operation.

DRY OR WET TYPES

Choose from all sizes of dry or wet (oil) friction linings to suit requirements of the individual application.

THE UTMOST CONTROL FLEXIBILITY

"GS" clutches can be actuated by virtually any switching device — manual or automatic . . . local or remote . . . push buttons, relays, limit switches, or electric eye. Operation can be adjusted for rapid, instant coupling — or slowed up for inching or jogging. Can be easily engaged manually in event of power failure.

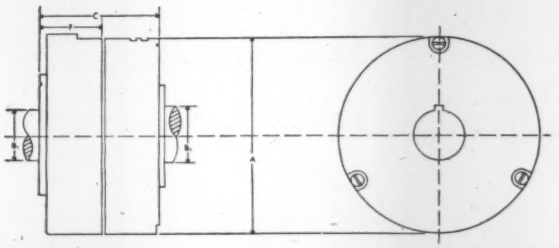
STEARNS "MINICON" RECTIFIERS

"GS" clutches are available for operation with 12, 24, 90, or 115 VDC. The new Stearns "Minicon" Rectifier — only 3″ wide x 4¾″ high — can handle the DC requirements of every model "GS" clutch presently available. It can be mounted in virtually any position or location — is highly efficient, simple, extremely dependable for many trouble-free years.

# of electro-magnetic disc clutches

Model "GS"...

41% on space - 33% on installed cost



For use on all types of power transmission control . . . machine tools . . . paper, textile, chemical, and food processing machinery . . . a size and type for every requirement.

MODEL NUMBERS		*SLIP TORQUE LB FT	WT. LB	WATTS	MAX. RPM	DIMENSIONS IN INCHES				
DRY	WET					"A" DIAMETER	"C" DEPTH	"F"	"B_1" MAX.	"B_2" MAX.
GS 402	GSW 404	9	11	18	4500	4½	3 3/16	1 7/8	7/8	7/8
GS 404	GSW 408	18	12	18	4500	4½	3 3/16	1 7/8	7/8	7/8
GS 406	GSW 412	27	13	18	4500	4½	4 5/16	1 7/8	7/8	7/8
GS 502	GSW 504	17	16	28	3600	5¼	3 5/8	2	1 3/8	1 3/8
GS 504	GSW 508	34	18	28	3600	5¼	4 1/16	2	1 3/8	1 3/8
GS 506	GSW 512	51	20	28	3600	5¼	4½	2	1 3/8	1 3/8
GS 702	GSW 704	80	37	60	3000	7¼	4 5/16	2 5/16	2	3
GS 704	GSW 708	160	40	60	3000	7¼	4¾	2 5/16	2	3
GS 706	GSW 712	240	43	60	3000	7¼	5 5/16	2 5/16	2	3
GS 902	GSW 904	180	71	70	2500	9¼	5 5/16	2 7/8	2 5/16	4
GS 904	GSW 908	360	75	70	2500	9¼	5½	2 7/8	2 5/16	4
GS 906	GSW 912	540	79	70	2500	9¼	5 13/16	2 7/8	2 5/16	4

*Clutch torque ratings are slip torque values. The nominal load torque should be multiplied by a factor sufficient to compensate for torque pulsations, shock loads, and type of driving and driven members peculiar to the individual application.

These new Stearns "GS" clutches give a new concept — an even greater range of application to the already comprehensive Stearns line of over 100 standard clutch and clutch-brake combinations . . . with a torque range from 0.4 to 120,000 lb ft . . . from business machines to ball mills, and larger. Stearns also custom designs units to your specific needs. 22

For complete electromagnetic clutch, clutch-brake, or brake data, call your local Stearns representative . . . or mail coupon direct to . . .

BRAKES MILWAUKEE Stearns WISCONSIN CLUTCHES

ELECTRIC CORPORATION

120 NORTH BROADWAY • MILWAUKEE 2, WISCONSIN

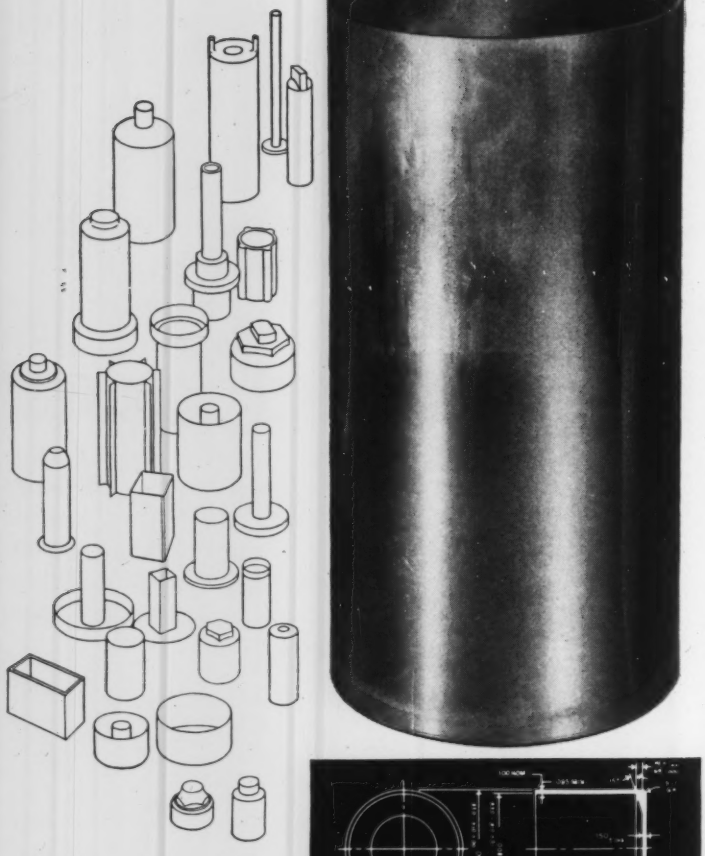
PLEASE SEND:

☐ Complete information on "GS" clutches.

☐ Complete clutch and clutch-brake data.

☐ Complete brake portfolio F.

To facilitate prompt receipt of this requested information, merely staple or clip this coupon to your business card or letterhead, with your name and address clearly indicated.



this **ALCOA IMPACT** solved a designer's problem

This large container represents the basic form of impact extrusion. Fabricated in one stroke of the press (as are all impacts), this part looks simple but would present problems if made by any other process. It is noteworthy on at least two counts to designers fighting to reduce material and fabricating costs:

First: it is a chest thumper for the designer who conceived it, because it reduces the cost of the part to one-fourth of the original estimate for other materials and conventional methods of fabrication. Its strong, seamless, easy-to-clean construction fits exactly the requirements for service as a sugar dispenser in an automatic coffee vending machine. *Second:* it is the largest diameter impact we are currently producing and gives you some idea of how big an impact can be. Large or small, simple or intricate, all impacts are completely fabricated in a fraction of a second with just one stroke of the press.

Sound too easy? Well, this is only the beginning. Using exactly the same techniques we can punch round, oval, square or special shapes. We can incorporate ribs, splines, flutes or other functional or decorative longitudinal patterns, on the inside or outside. In fact, just about any closed end tubular part or cup-shaped part should be considered as an Alcoa® Impact. We don't know what we'll be working on next. We'd prefer to be limited only by your imagination.

To get your thinking started, send for Alcoa's design manual, *Alcoa Impacts—Metal in Motion*. For immediate help with any problems, call your Alcoa sales engineer. You'll find the nearest Alcoa sales office listed under "Aluminum" in the Yellow Pages of your phone book. Aluminum Company of America, 1991-H Alcoa Building, Pittsburgh 19, Pa.

Some Impact Rules of Thumb—
Check your problems against this list:

1. Parts requiring hollow sections—either tube or cup-shaped with one end closed.
2. Parts with walls or surfaces requiring zero draft.
3. Parts requiring lengths up to eight or ten times the diameter.
4. Parts requiring the strength of forgings.
5. Parts requiring tolerances down to $\pm 0.005''$.
6. Parts requiring ribs, bosses or fins as integral parts.
7. Parts requiring low unit cost in mass production. (Often the savings in machining, fabrication and assembly made by impacts amortize tooling in relatively short runs.)

ALCOA ALUMINUM IMPACTS
ALUMINUM COMPANY OF AMERICA

YOUR GUIDE TO THE BEST IN ALUMINUM VALUE

THE ALCOA HOUR
TELEVISION'S FINEST LIVE DRAMA
ALTERNATE SUNDAY EVENINGS

Circle 438 on page 19

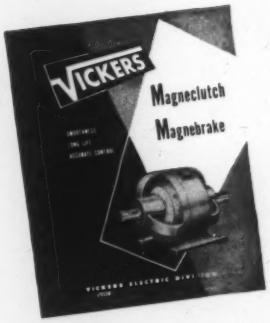
there's No Wear...

in the

VICKERS® MAGNECLUTCH

DRY MAGNETIC-PARTICLE CLUTCH

because there's no mechanical contact between torque transmitting surfaces



Vickers MAGNECLUTCH may also be used for braking and tension control. Get the complete facts. Write today for bulletin and application data forms.

There are no levers or linings—no spring, air or fluid pressures in the Vickers MAGNECLUTCH. Torque is transmitted by the linking action of magnetized finely divided ferromagnetic particles in the gap between driving and driven members. Torque is independent of speed, and is determined by the amount of energizing current. This torque transmission principle provides

CONTROLLED ACCELERATION*
SMOOTH OPERATION
NO GRAB OR CHATTER
LONGER LIFE

Vickers **MAGNECLUTCH** also Offers the Advantage of

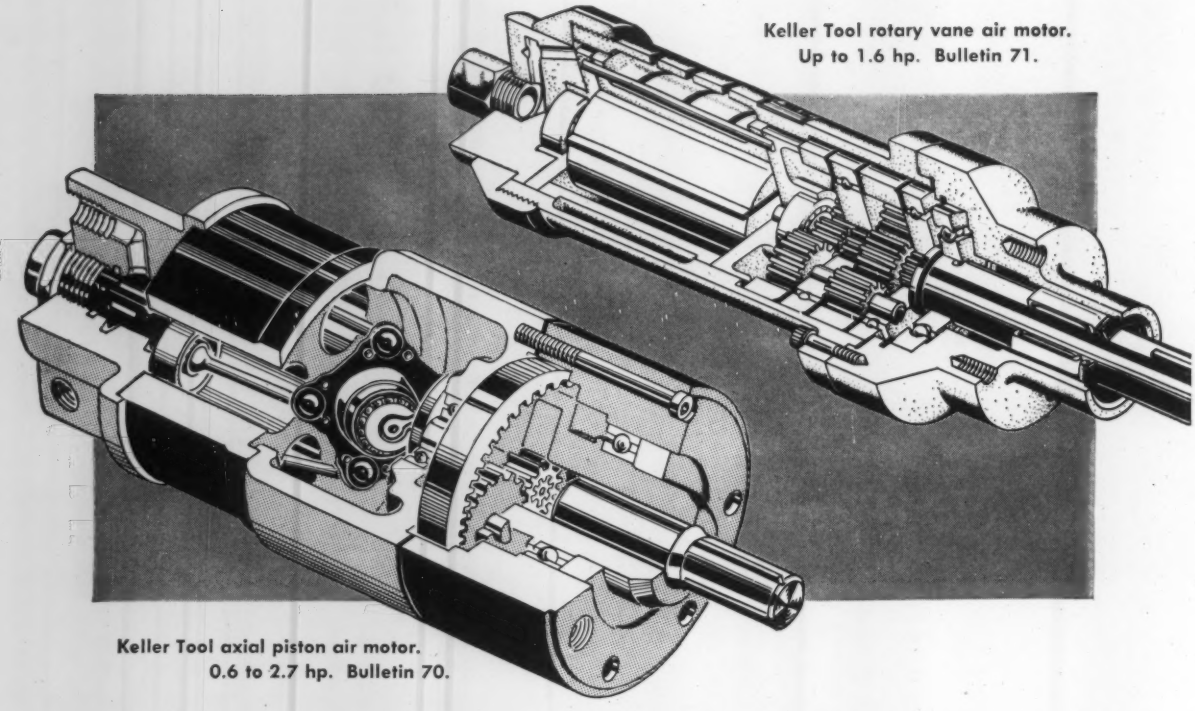
TORQUE AT ZERO SLIP—
torque transmitted with 100% mechanical efficiency
TORQUE LIMITING—
torque easily adjustable from minimum to full rated torque
EXTREMELY FAST RESPONSE
SMALL CONTROL POWER
EASILY ADAPTED TO REMOTE CONTROL

*Equally close control of deceleration may be obtained with the Vickers MAGNEBRAKE.

VICKERS ELECTRIC DIVISION

VICKERS Inc. a unit of Sperry Rand Corporation

1881 LOCUST STREET • SAINT LOUIS 3, MISSOURI



Keller Tool rotary vane air motor.
Up to 1.6 hp. Bulletin 71.

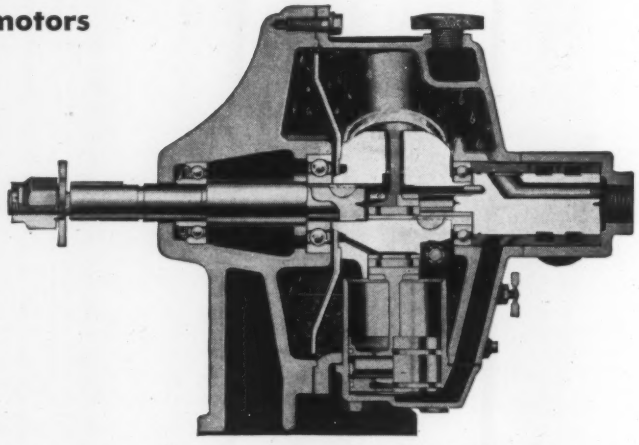
Keller Tool axial piston air motor.
0.6 to 2.7 hp. Bulletin 70.

Air power is idea power . . .

when your design calls for motors with these features:

High starting torque
Reversibility without power loss
Variable speed, easily controlled
Cool operation
Instantaneous starts and stops
Consistent torque output
Non-sparking characteristics
Thrust and axial spindle loads
Enclosed construction
Output from ½ to 16 hp.

AIR MOTORS are your answer
Write for detailed bulletins.



Gardner-Denver five-cylinder radial
air motor. 3 to 16 hp. Bulletin AM-1.

ENGINEERING FORESIGHT—PROVED ON THE JOB
IN GENERAL INDUSTRY, CONSTRUCTION, PETROLEUM AND MINING

GARDNER - DENVER

Gardner-Denver Company, Quincy, Illinois

Circle 440 on page 19

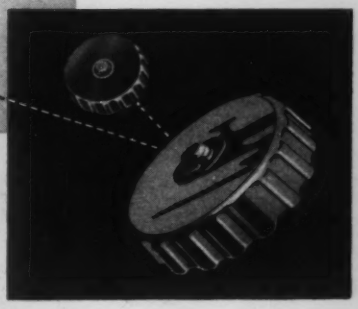
Put your finger on

IMPORTANT COST REDUCTIONS

For Controls, Meters and Miniature Instruments

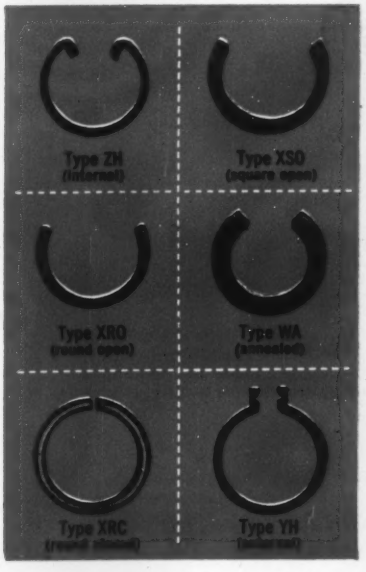
Save time and materials ***...and*** **improve your products** ***with...***

NATIONAL Retaining Rings conserve valuable space in portable equipment, pocket radios, hearing aids, controls, meters, instruments and miniature assemblies. Weight savings and reduction of manufacturing costs are added advantages.



NATIONAL

RETAINING RINGS



Simplify design by specifying NATIONAL Retaining Rings on shafts and housings. These dependable rings save material, weight and assembly time wherever shoulders or collars are required. Grooving smaller diameters for retaining rings avoids cutting down larger diameter material to form shoulders and collars . . . saves costly machining, speeds assembly. NATIONAL Retaining Rings are service-proven on all types of equipment from heavy machinery to miniature assemblies. Ask for all the cost-saving facts, today!

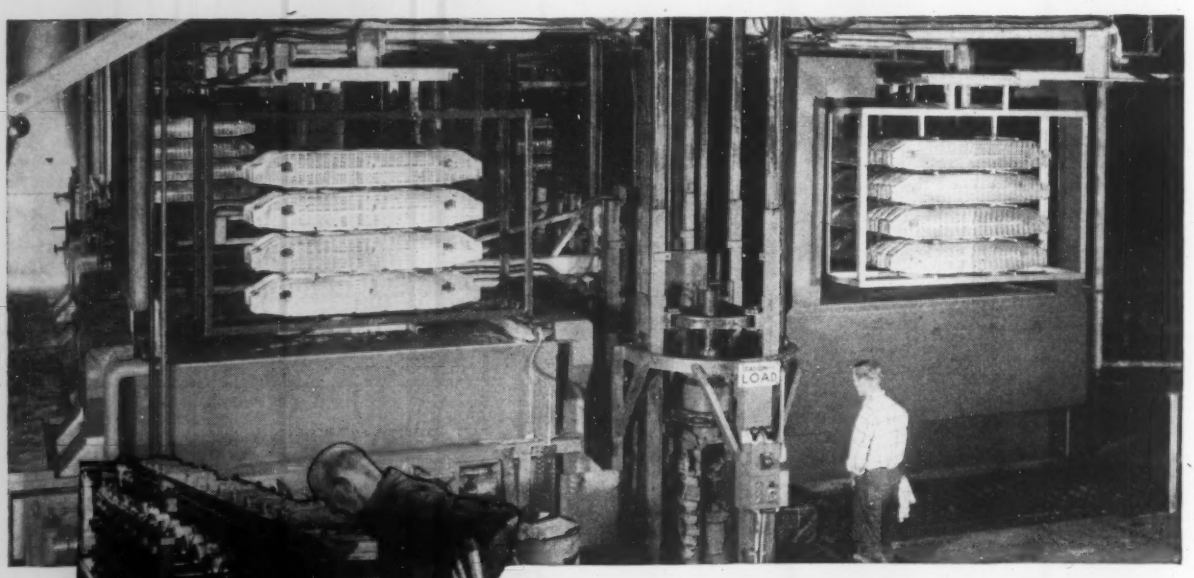
THE NATIONAL LOCK WASHER COMPANY

Serving Industry Since 1886

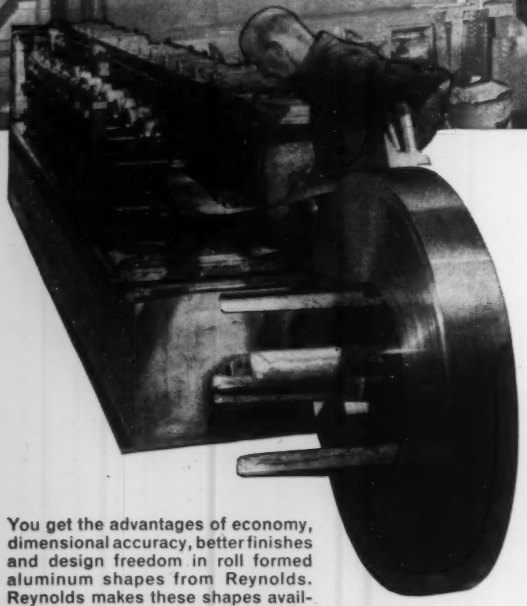
NEWARK 5, NEW JERSEY
MILWAUKEE 2, WISCONSIN

Circle 441 on page 19

Here's how
REYNOLDS ALUMINUM



This new Reynolds automatic aluminum finishing system can finish mixed sizes and types of parts and chemically brighten or anodize them in different colors—and can handle several different jobs at the same time. An automatic coding system establishes the individual finishing specifications for each job.



You get the advantages of economy, dimensional accuracy, better finishes and design freedom in roll formed aluminum shapes from Reynolds. Reynolds makes these shapes available in embossed patterns, paint finishes and plain or color anodized finishes.

Brazing, (above) and welding, (left) are daily fabricating operations at Reynolds. Crater-free fusion welding, inert-gas-shielded metal arc welding and other types of welding are handled quickly, efficiently at Reynolds.

See "CIRCUS BOY", Sundays, NBC-TV.
Watch for Reynolds on "DISNEYLAND", ABC-TV.

FABRICATING FACILITIES

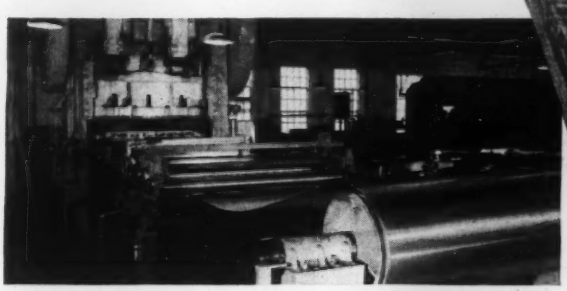
assure efficient, economical production of the products you design

If the products (or parts for products) you are designing call for aluminum, Reynolds fabricating and finishing facilities may be the answer to low cost, fast, quality production. Here's why:

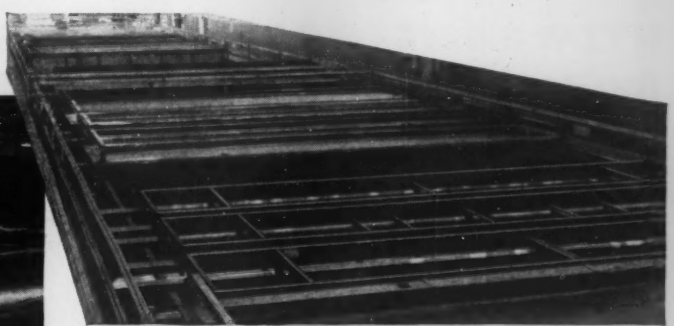
Reynolds has the right type of *equipment* for fabricating and finishing aluminum parts. There are good examples of some of this modern equipment on these pages. Reynolds has the *experience* . . . has the technological know-how in producing and fabricating aluminum. Reynolds guarantees *quality* . . . controls it from mine to finished part.

These advantages of facilities, experience and quality control add up to savings of many kinds. Savings in capital outlay for equipment and added plant capacity. Released floor space. Reduced raw material inventory. Elimination of scrap loss, scrap handling expense and reject costs. And this combination of advantages points the way to increased flexibility of design with the assurance of quality production of the products you design.

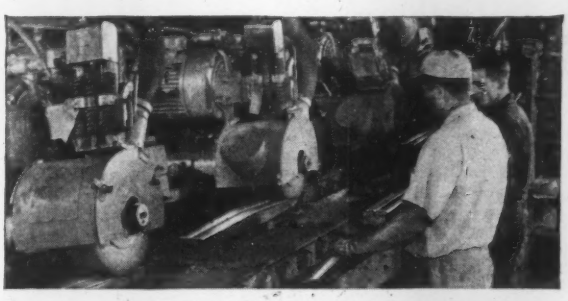
Send for Reynolds "Complete Facilities" brochure. And for the assistance of Reynolds Styling and Engineering Service and for details on Reynolds fabricating and finishing facilities, contact your nearest Reynolds Office or write *Reynolds Aluminum Fabricating Service, 2061 So. Ninth St., Louisville, Ky.*



Over 200 pieces of major fabricating equipment are available in just two Reynolds plants alone. Above is part of a battery of Reynolds new high speed coil fed presses.



This new Reynolds half-block long anodizing installation can handle parts up to 24' long, 12' high and 4' wide.



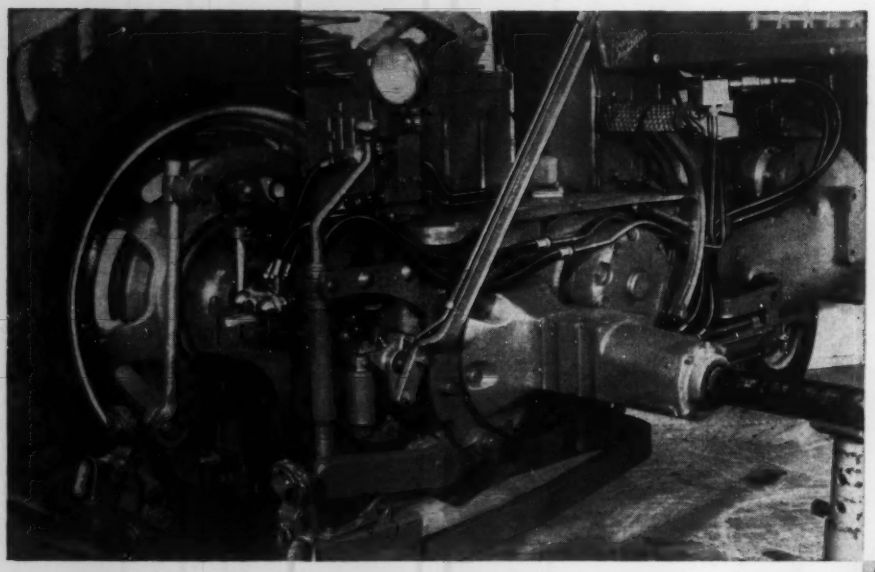
Scratch-brushing, satin finishing, embossing and other mechanical finishes are available from Reynolds. Here is part of a battery of Reynolds new high speed buffing equipment.

The Finest Products Made with Aluminum are made with REYNOLDS ALUMINUM

REYNOLDS ALUMINUM
Fabricating Service

BLANKING • EMBOSSING • STAMPING • DRAWING
RIVETING • ROLL SHAPING • TUBE BENDING
FORMING • WELDING • BRAZING • FINISHING

Circle 442 on page 19



INTERNATIONAL HARVESTER'S

McCORMICK FARMALL 400

Tractor controls every implement action hydraulically through its famous Hydra-Touch hydraulic system. Individual, closely grouped levers permit independent or unison control of cylinders.

HYDRAULIC POWER . . . DELIVERED THROUGH

Eastman

HYDRAULIC HOSE ASSEMBLIES . . .

Most competitive Farm Implement Sales Feature

HYDRAULIC POWER probably contributed more to the usefulness, efficiency, and easy operation of farm tractors than any other modern engineering development. Farmers appreciate hydraulic advantages so much that they have become one of the *most competitive features in implement and tractor sales promotion.*

EASTMAN MANUFACTURING COMPANY is proud to have among its many agricultural users the International Harvester Company—dating back to the first McCormick Reaper—in 1831. Eastman—*first in the field* of Hydraulic Hose Assemblies—lists many other agricultural implement manufacturers among its users: J. I. Case, Allis-Chalmers, Massey-Harris-Ferguson, Inc., Minneapolis-Moline, Farmhand, Avco, and others.

IMPROVE THE COMPETITIVE POSITION OF YOUR PRODUCTS with Hydraulic Power—delivered through Eastman Hydraulic Hose Assemblies. Always specify Eastman: First in exclusive engineering advantages and design! First in materials and workmanship! *First in the field* of Hydraulic Hose Assemblies!

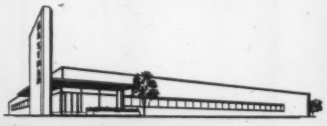
HYDRAULIC POWER controls plow penetration and depth automatically, lifting and locking in traveling position.

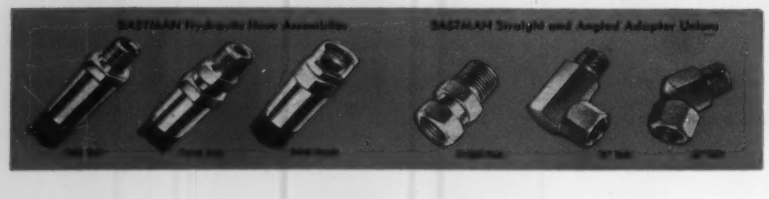
HYDRAULIC POWER controls angle and depth of disc penetration on International Fast-Hitch Bush and Bog Harrow.

HYDRAULIC POWER enables Farmall 200 Hydra-Creeper to travel 1/5 to 1 mile per hour for transplanting.

HYDRAULIC POWER permits raising right, left, or rear cultivator gangs separately, together, or any combination.

WRITE **Send your specifications and blueprints for our original equipment quotations.**





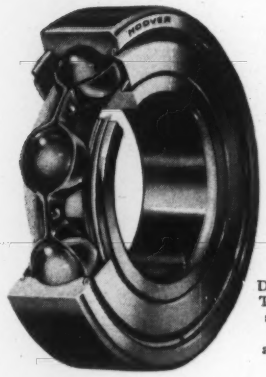
Eastman

first in-the-field

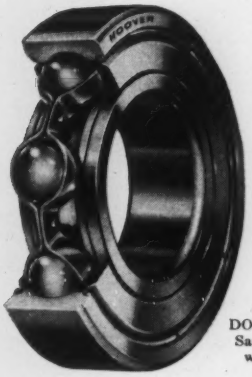
MANUFACTURING COMPANY

Dept. MD-8, Manitowoc, Wis.

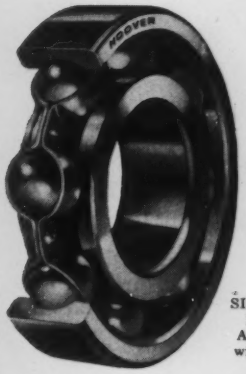
Circle 443 on page 19



DOUBLE SEAL—
Teflon contact seal shown. Available with snap ring and with single or double seal.

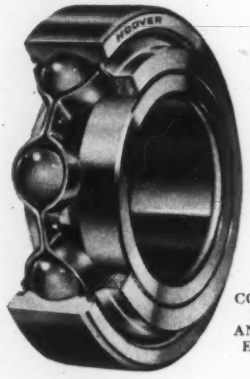


DOUBLE SHIELD—
Same sizes available with single shield.

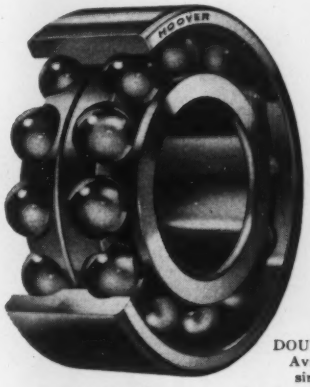


SINGLE ROW RADIAL—
Also available with snap ring.

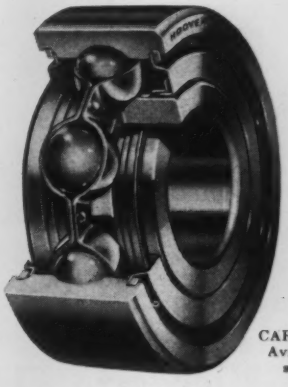
when you want quality



COMBINATION FELT SEAL AND SHIELD—
Either standard or wide outer ring.



DOUBLE ROW—
Available with single shield.



CARTRIDGE—
Available with snap ring.

you want hoover

When you want *quality* bearings to add to the performance, long life and smooth operation of your products, you want Hoover Ball Bearings.

Hoover Ball Bearings combine the exactness of *Micro-Velvet* Lapped Balls with the smoothness of *Hoover Honed* Raceways. The result . . . top quality bearings that assure unexcelled performance —quietness—long life—and heavy load capacity.

Investigate Hoover's line of ball bearings in the light, medium and heavy series. Their microscopic precision adds up to your best buy in ball bearings. Manufacturers are invited to call in Hoover engineers for technical assistance. Write for information.

Micro-Velvet and *Hoover Honed* are Hoover Trademarks.

HOOVER BALL AND BEARING COMPANY, ANN ARBOR, MICHIGAN

Send information about

- ☐ Single Row Radial Bearings
- ☐ Bearings with Shields
- ☐ Bearings with Seals
- ☐ Combination Shield and Seal
- ☐ Cartridge Bearings
- ☐ Double Row Bearings

Hoover Ball and Bearing Company, Ann Arbor, Mich.

Please send information checked. Mail copy of "Hoover Handi-Book of Anti-Friction Bearings."

Name_____

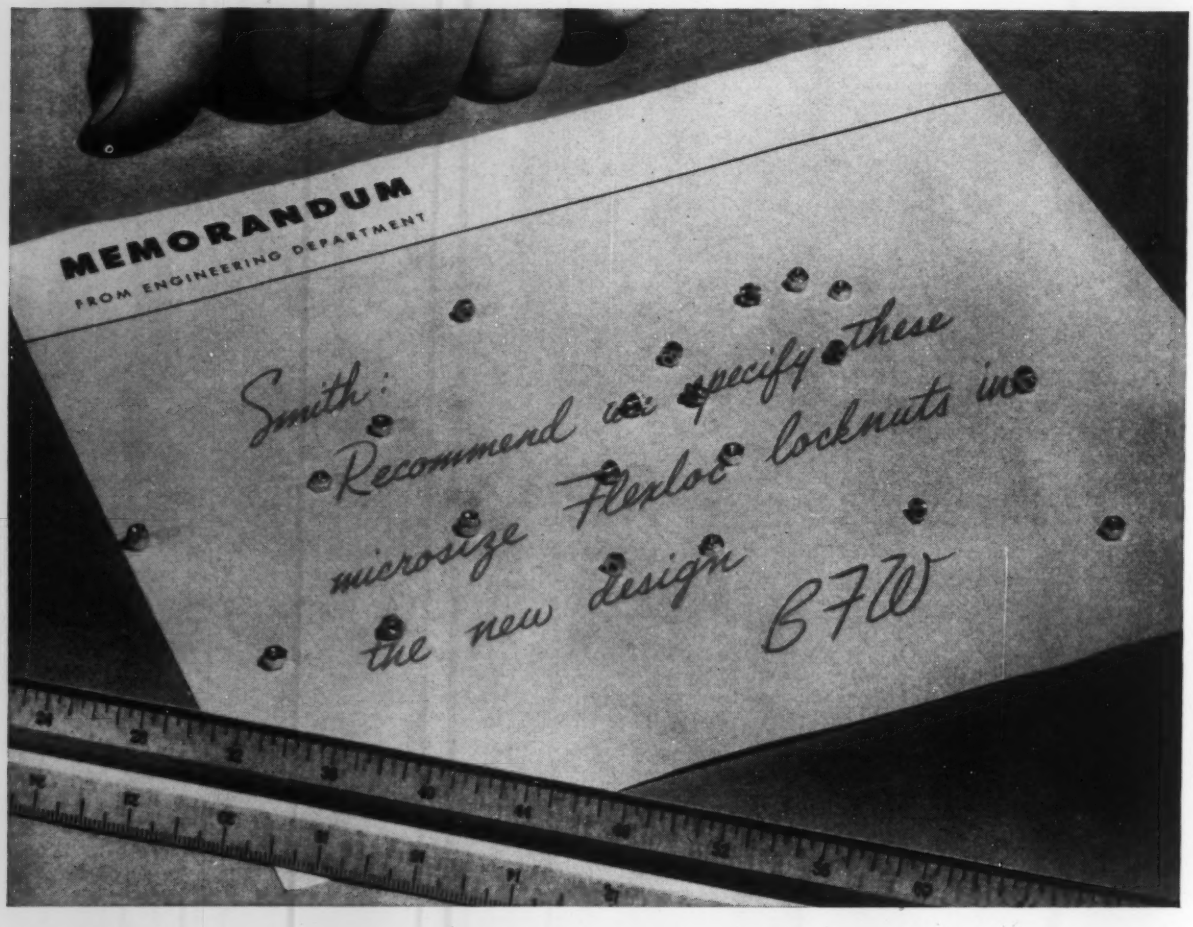
Title_____

Company_____

Address_____

City_____ State_____

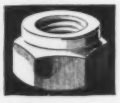
MD



Microsize FLEXLOC locknuts help you design smaller assemblies and fasten them securely

SIZE	Across Flats MAX.	Across Flats MIN.	Hex. Height REF.	Across Corners MIN.	Height REF.
0-80 NF-3B	.111	.107	.046	.121	.075
1-64 NC-3B	.127	.123	.056	.140	.090
1-72 NF-3B	.127	.123	.056	.140	.090
2-56 NC-3B	.158	.153	.067	.176	.105
2-64 NF-3B	.158	.153	.067	.176	.105
3-48 NC-3B	.190	.183	.071	.210	.120
3-56 NF-3B	.190	.183	.071	.210	.120
4-40 NC-3B	.190	.183	.071	.210	.120
4-48 NF-3B	.190	.183	.071	.210	.120

Standard microsize FLEXLOC locknuts are available in brass (plain or cadmium plated) and aluminum (plain or chemically treated) for temperatures up to 250°F; in alloy steel (plain or cadmium plated) and 18-8 stainless steel (silver plated) for temperatures up to 550°F.



Microsize FLEXLOC locknuts save space and reduce weight in electronic equipment, instruments, servomechanisms, and other small assemblies in which weight and bulk are important design considerations. Microsize FLEXLOC locknuts are smaller and lighter than regular FLEXLOCS of the same nominal diameter. They permit smaller mating joints or flanges —with no loss in holding power or convenience of assembly.

Like regular FLEXLOCS, microsize FLEXLOC locknuts are of one-piece, all-metal construction. No inserts to pop out or deteriorate; nothing to put together, come apart or get lost. FLEXLOCS lock and stay locked wherever wrenching stops. You can use them as locknuts or stop nuts. Vibration will not loosen them and they can be used many times over.

For more information on microsize FLEXLOC locknuts (or microsize FLEXLOC self-locking clinch nuts), see your local FLEXLOC distributor or write STANDARD PRESSED STEEL CO., Jenkintown 18, Pa.

STANDARD PRESSED STEEL CO.

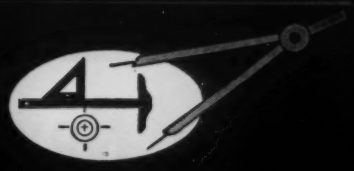
FLEXLOC® LOCKNUT DIVISION SPS JENKINTOWN PENNSYLVANIA

Circle 445 on page 19

USING

DU PONT ELASTOMERS

neoprene · Hypalon®



in design

New NEOPRENE closure strip weatherproofs corrugated roofing and siding

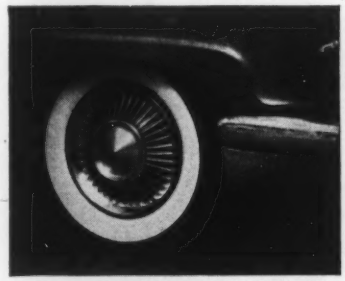
Tire sidewall of HYPALON® stays white, resists sunlight, ozone

A leading tire manufacturer has greatly improved the appearance and performance of whitewall tires by using a special rubber compound which includes a substantial amount of HYPALON, Du Pont's new synthetic rubber. Road tests in the Los Angeles area show that the inclusion of HYPALON keeps the sidewall from cracking and becoming discolored.

Chief reason for this success is the outdoor stability of HYPALON. Minute traces of ozone in the air are the primary cause of whitewall deterioration, but HYPALON is *completely unaffected by ozone*. It also withstands sunlight, weathering and discoloration far better than other kinds of rubber.

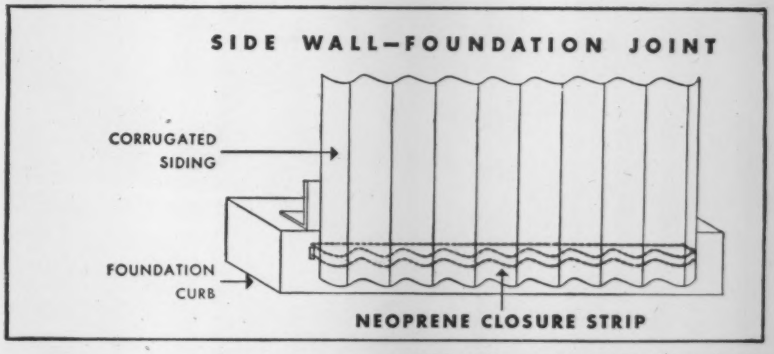
Idea for extra-long service

HYPALON also has many other properties of interest to designers. It shows unusual resistance to hardening at elevated temperatures (250°-350°F.) and has excellent resistance to solvents and chemicals, including strong oxidizing agents. These properties make HYPALON a wise choice for use in many industrial products, such as gaskets, molded parts, diaphragms, belt, hose—any resilient product that must give long cost-saving service where service conditions are severe. Just clip coupon for more information about HYPALON.



Lasting whiteness for sidewalls is now a reality with HYPALON. This versatile synthetic rubber can also be compounded in an unlimited range of light-fast colors.

Circle 446 on page 19



(Above) Diagram shows position of neoprene closure strip on side wall. (Left) Close-up shows manner of bolting neoprene strip to flashing section.

Elastic strip withstands temperature extremes... eliminates caulking

A new neoprene closure strip has been developed which, according to the manufacturer, will solve the problem of weatherproofing corrugated roofing and siding. Only an inch wide, this non-porous closed-cell neoprene closure strip is die-cut to fit corrugations, forming a snug seal. Neoprene's long service life assures lasting protection for a building's exterior from dust, dirt, water and air—at minimum maintenance.

The closure strips are installed on roofing under the aprons of ridge roll and under flashing sections at roof junctions and side walls. They're fastened at the same time as the corrugated sheeting. No separate caulking is required.

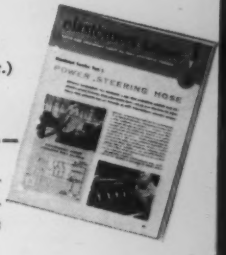
Neoprene's elasticity and lasting resistance to weathering, temperature extremes and aging are vital to the success of the closure design. The strip *stays* elastic, won't become brittle and then crack in cold weather or become soft and sticky in hot weather. You may find just the properties your designs need in neoprene, Du Pont's versatile synthetic rubber. For more information, just clip the coupon.

Hundreds of feet of neoprene closure stripping are used at roof, side wall, window and door junctures of this typical building.

DU PONT
REG. U.S. PAT. OFF.

HYPALON *is a registered trademark of E. I. du Pont de Nemours & Co. (Inc.)*

BETTER THINGS FOR BETTER LIVING . . . THROUGH CHEMISTRY



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Elastomer Chemicals Dept. MD-8
Wilmington 98, Delaware

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*Address*_____
*City*_____ *State*_____

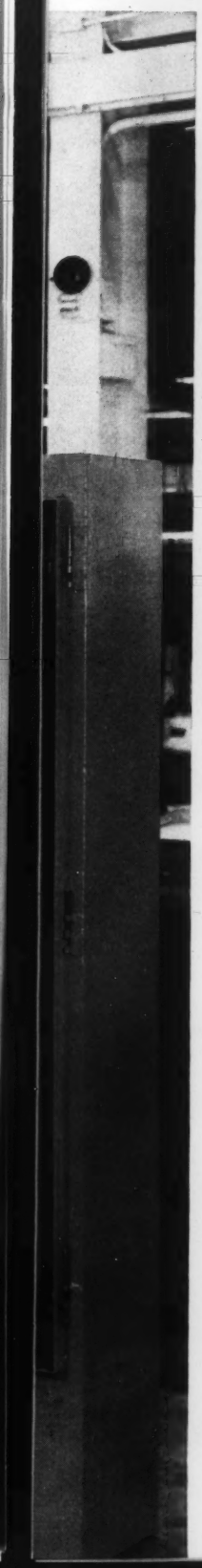
New microhoning machine uses

ASK FOR YOUR NEW G-E
THYMOTROL SELECTOR GUIDE TODAY

To help you in selecting a general-purpose Thymotrol drive, General Electric has prepared a new selector guide. This easy-to-use selector puts basic data on ratings, frame sizes, dimensions, and model numbers right at your fingertips.

For your selector guide—covering both fractional and integral drives up to 3 HP—call your nearest G-E Apparatus Sales engineer today.

General Electric Thymotrol* drives to speed cutting, boost accuracy



Eight General Electric general-purpose Thymotrol drives—costing up to $248† *less* than other electronic adjustable-speed drives—are precisely controlling the expansion motions of Micromold tools on Micromatic's new machine.

Micromatic Hone Corporation formerly used only hydraulic control in this operation. Now, with G-E Thymotrol drives, they are able to utilize a new type of tool resulting in greater accuracy, improved cutting action, and easier remote operation—***all*** at low initial investment.

This is but one of the wide range of G-E general-purpose Thymotrol applications. Today, these job-tailored drives are being used on transfer machinery, machine tools, process pumps, testing equipment—in fact—they are being applied to almost any machine whose performance can be improved with adjustable speed.

OUTSTANDING BENEFITS

Backed by years of leadership in the design, manufacture, and application of adjustable-speed drives, General Electric Thymotrol drives offer:

Increased production—right speed provided for every requirement.

Increased machine versatility—wide speed range and close speed regulation permit use of same machine on a variety of work.

Reduced downtime, lower maintenance—design features such as swing-out panels, readily accessible components make maintenance a fast, simple job. Beyond normal lubrication, little maintenance is required since there are no moving parts in the control to wear out or break down.

All G-E general-purpose Thymotrol panels have a written one-year warranty—an expression of G.E.'s confidence in their reliability.

SELECT THE DRIVE YOU NEED —AND SAVE MONEY!

When you select Thymotrol drives you get the perfect combination—***outstanding performance at low price.*** See your G-E Apparatus Sales engineer today or write for Bulletins GEA-6234 and GEA-6519 to Sect. 791-4, General Electric Co., Schenectady 5, N. Y. *Specialty Control Dept., Waynesboro, Va.*

*Reg. Trade-mark of General Electric Company.

†1/10 HP, 220-volt AC input, general-purpose Thymotrol drives.

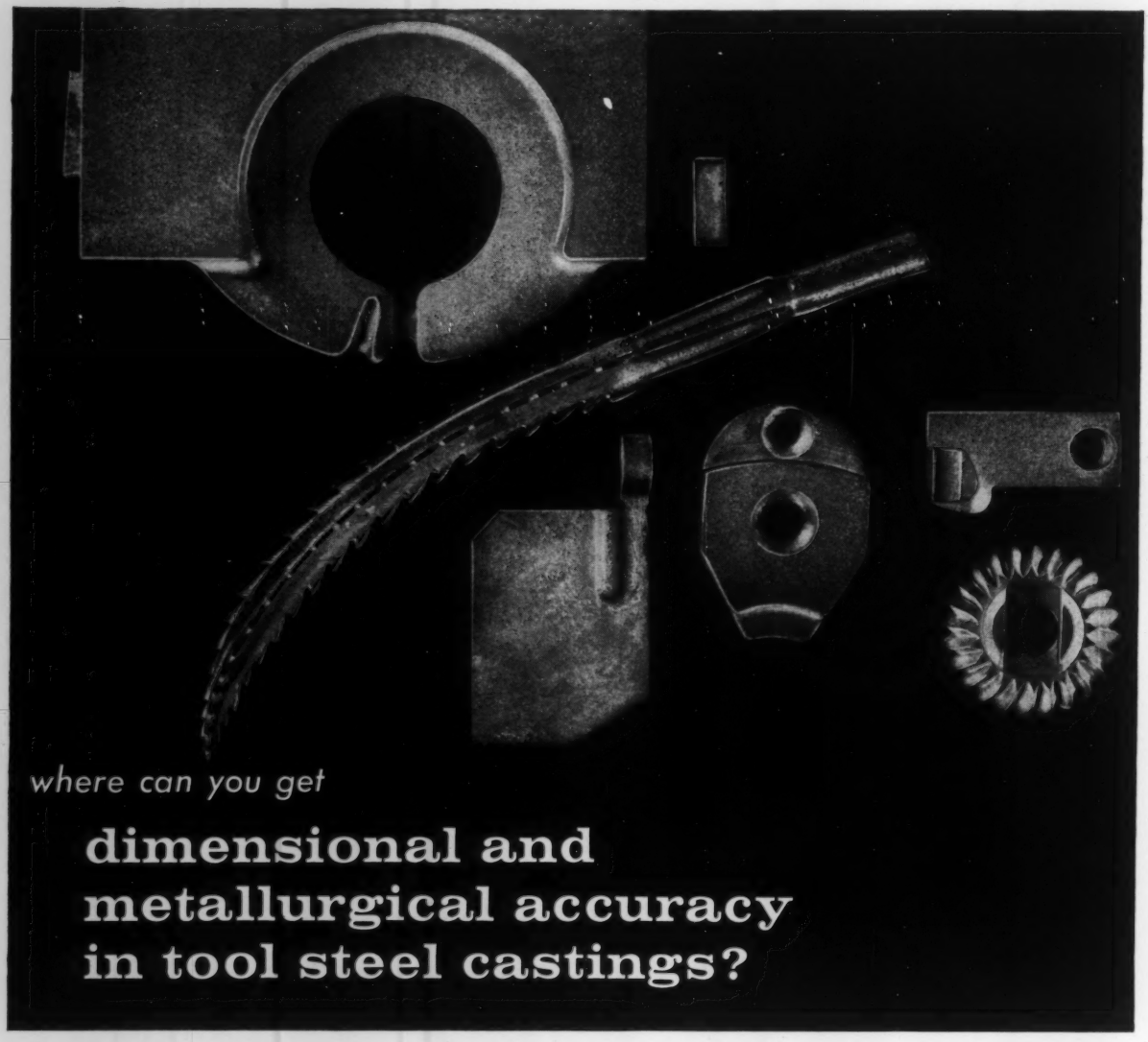
Progress Is Our Most Important Product

GENERAL ELECTRIC

COMPARE AND PROVE GENERAL ELECTRIC'S SUPERIORITY

FEATURES	G-E THYMOTROL DRIVE	DRIVE A	DRIVE B	DRIVE C	DRIVE D
Speed range of 20 to 1 or more	✓			✓	✓
Printed circuitry	✓		✓		
Flat regulation at any pre-set speed	✓		✓		
Current limit acceleration	✓				
Regulation of 5% or less	✓		✓	✓	
Quick slowdown	✓	✓			
New NEMA motor sizes	✓				

Circle 447 on page 19



where can you get

dimensional and metallurgical accuracy in tool steel castings?

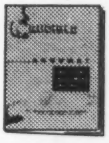
The quality of tool steel castings depends heavily on metallurgical control and foundry techniques which can be acquired only through long experience in handling tool steels. That's why it will pay you to get your castings directly from Crucible, largest and leading producer of tool steels.

Only Crucible can furnish precision castings in Ketos, Rexalloy, Rex M-2, Rex AA, Airkool, HYCC and Airdi 150—tool steels that solve wear, abrasion and temperature problems when ordinary alloys fail.

Crucible Accumet® Precision Investment Tool Steel Castings are regularly produced with a tolerance of ±.005″ (and even ±.002″ or ±.003″) and a surface finish of 125 RMS to 62 RMS... and in almost any shape or configuration.

Uniformity in response to heat treatment. Crucible quality control, from heat to heat, and complete inspection facilities ensure the uniformity in hardenability so necessary for successful tool steel castings.

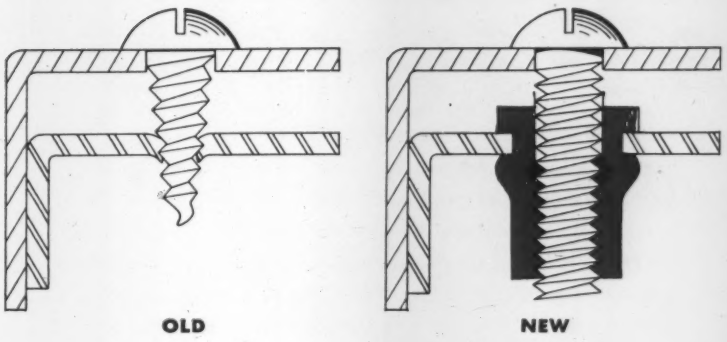
Crucible Accumet Tool Steel Castings can help you reduce costs and improve product performance. Consider Crucible's extensive facilities and experience when you need either investment or sand castings. Write for free booklet to: *Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pennsylvania.*



CRUCIBLE first name in special purpose steels

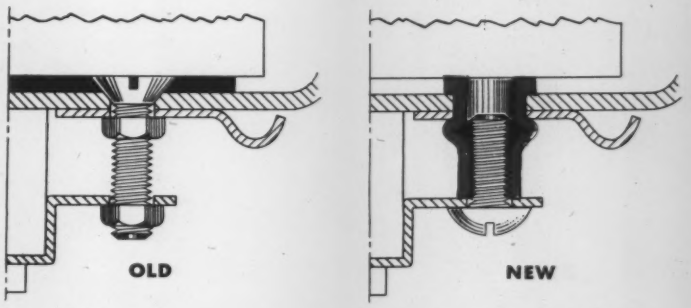
Crucible Steel Company of America

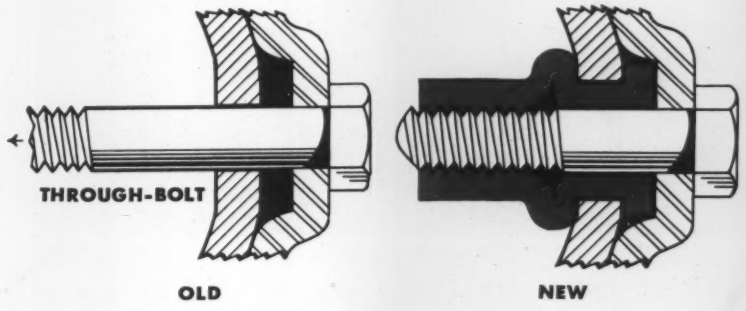
Compare B. F. Goodrich Rivnuts®
with other fastening methods



RIVNUTS ARE STRONGER—Installing retaining clips in aluminum storm doors with ordinary self-tapping screws involved service problems for the manufacturer. Screws enlarged the holes, pulled out, and larger screws had to be substituted by the user. But B.F.Goodrich Rivnuts provided a firm, accurate nutplate that didn't loosen with shock, vibration or repeated use. Six clean threads eliminated any pulling or tearing of metal during assembly or later. The B.F.Goodrich Rivnuts speeded assembly, too, because installation took only a few seconds.

RIVNUTS SAVE MONEY—Assembling vaporizers the old way required a reinforcing plate with two machined countersunk holes for the bolt heads. In addition, the bolts frequently turned and tightened, bending the lower flange out of alignment. Using B.F.Goodrich Rivnuts, the reinforcing plate could be removed and the lower flange held secure without bending. Result—a better product, requiring less assembly time and fewer parts, and a substantial over-all cut in production costs.





RIVNUTS FASTEN BLIND—Using conventional nuts and bolts it took two men to fasten arm brackets on street lights. Now one worker in the factory installs Rivnuts in the aluminum pole. The assembler merely slips the slotted part of the arm bracket over a bolt in the lower Rivnut, puts the top bolts in place and tightens all three. Assembly costs are lower by 50% because one man now does the work of two. And tests show that the pole or arm bracket will fail before the Rivnut.

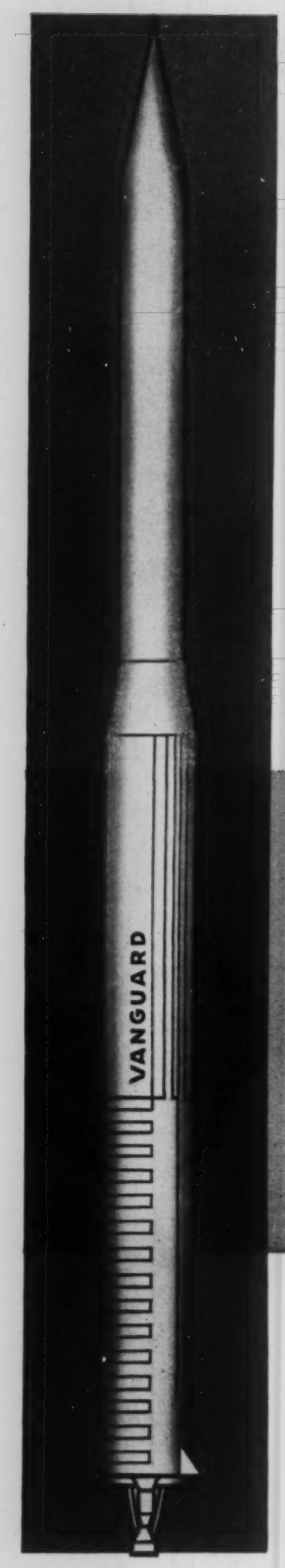
Free Rivnut demonstrator shows with motion how Rivnuts fasten *to* and *with*. To get yours, write: B.F.Goodrich Rivnuts, Department MD-87, Akron, Ohio.

B.F.Goodrich

B.F.Goodrich Aviation Products

a division of The B. F. Goodrich Company, Akron, Ohio

Circle 449 on page 19



VICKERS®

miniaturized motorpumps

...for Vanguard Earth Satellite Rocket Vehicle

Numerous Vickers miniaturized hydraulic airborne components have been successfully developed for missile use without sacrifice of their inherent high efficiency and reliability. Representative of the "packaged" approach to dependable missile hydraulic power is the PFM-3906 constant displacement piston type pump shown here mounted on an electric motor. The pump has a theoretical delivery of 0.84 gpm at 7400 rpm and 1000 psi with a volumetric efficiency of 95%. The explosion proof motor has 6.0 in.-lb. torque from 6900 to 9000 rpm. The complete package weighs 8 lb. . . . 1 lb. for the hydraulic pump and 7 lb. for the electric motor. **The overall length is less than 10 inches.** For further information about Vickers miniaturized hydraulic components and complete packages, ask for Bulletin A-5216.

7886

VICKERS INCORPORATED

DIVISION OF SPERRY RAND CORPORATION

Aero Hydraulics Division • Engineering, Sales and Service Offices:

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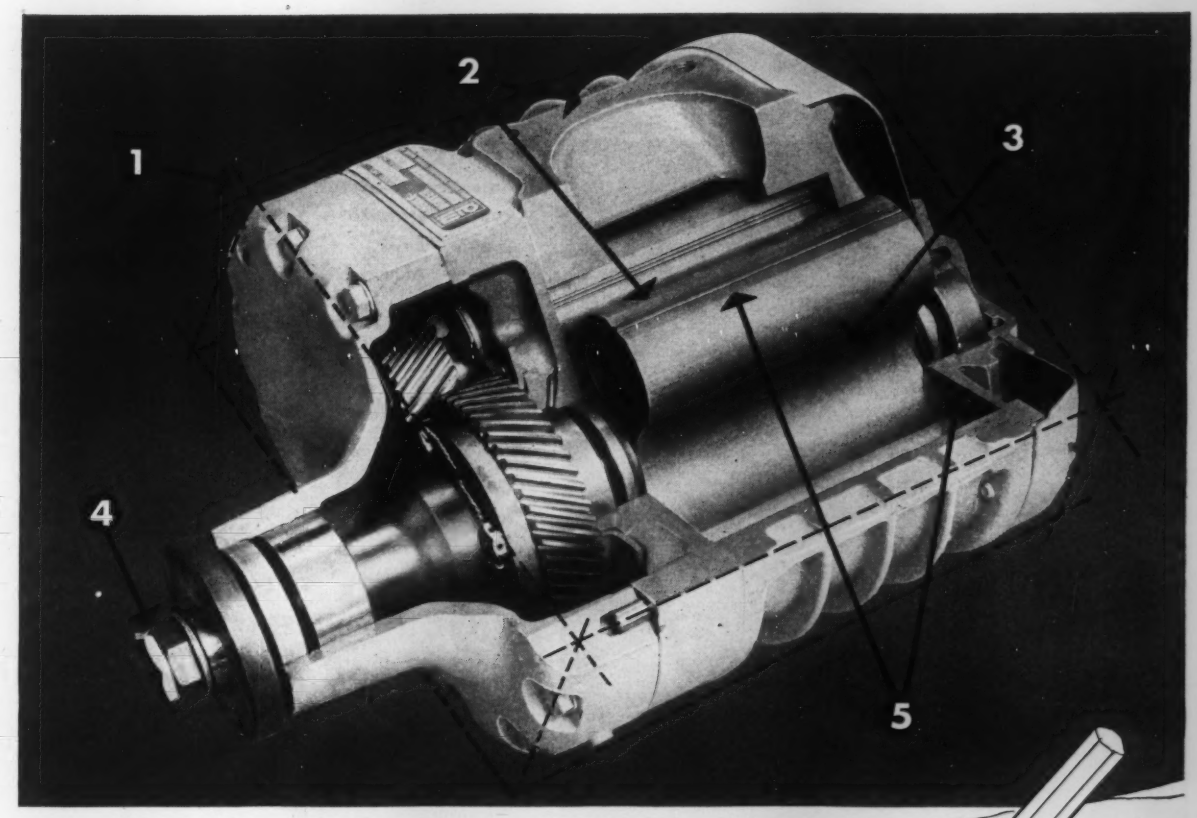
ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

Circle 450 on page 19



The BIG difference in blowers is...

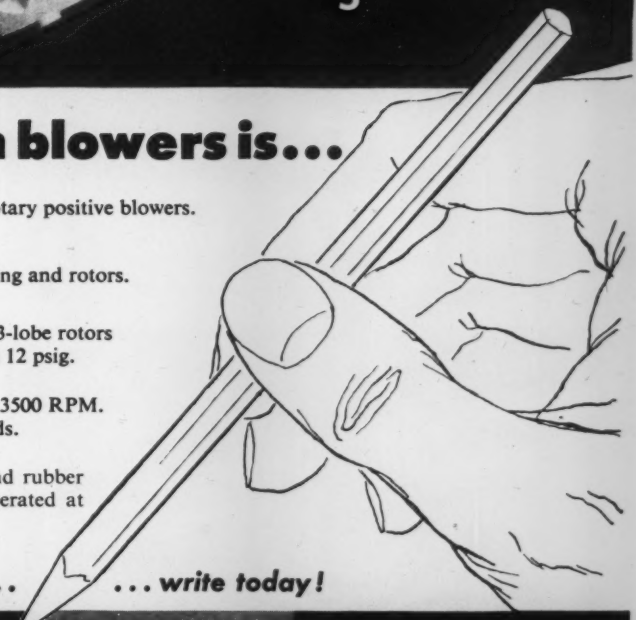
HERE 1 Smallest cube dimensions of all rotary positive blowers.

HERE 2 Lightest weight with aluminum housing and rotors.

HERE 3 Wide pressure range—exclusive 3-lobe rotors deliver pressures from 1 through 12 psig.

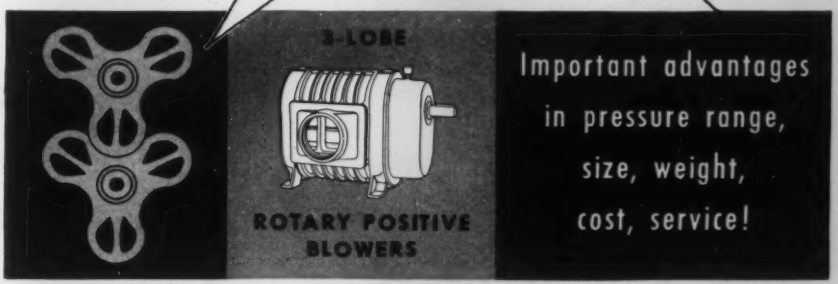
HERE 4 Direct drive at 1160, 1750 and 3500 RPM. Belt drive at intermediate speeds.

AND HERE 5 Exclusive formica wear strips and rubber grid seals prevent freezing if operated at excessive pressures.



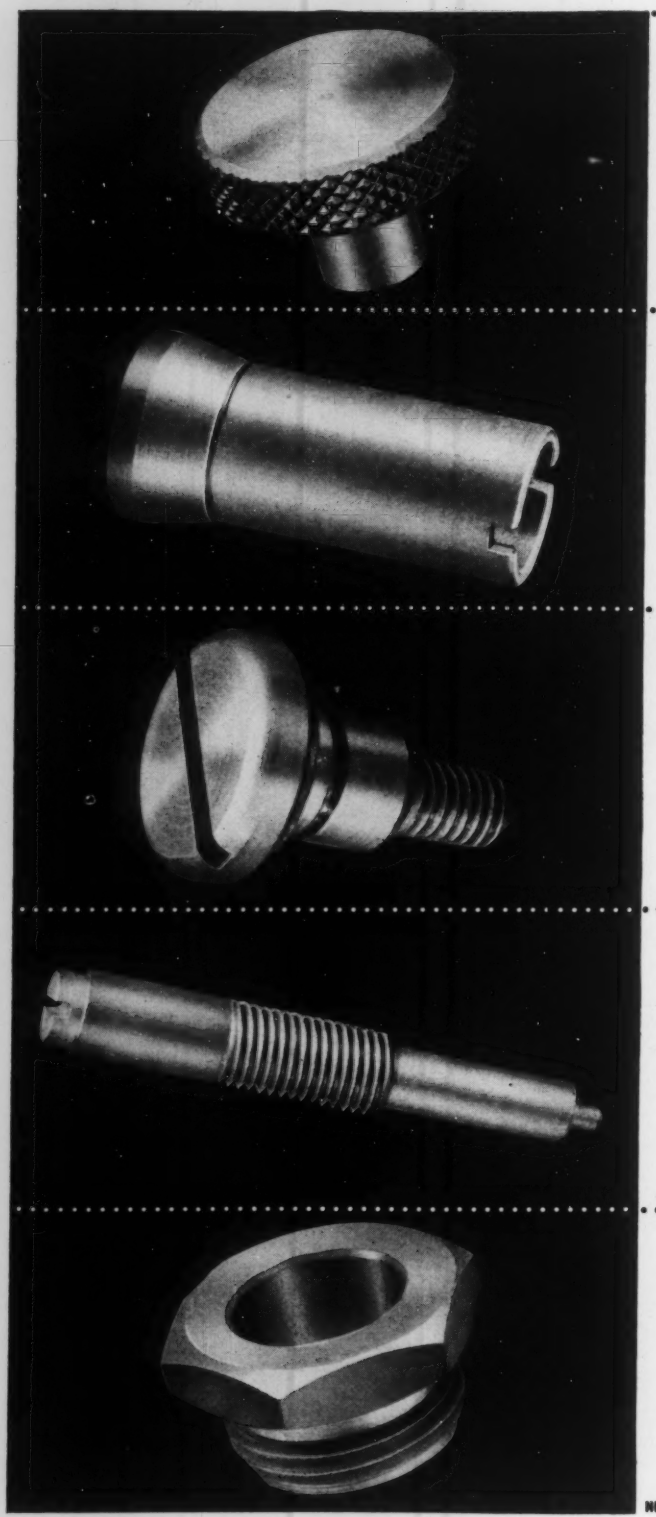
The performance figures are convincing... ...write today!

Miehle Dexter



Miehle-Dexter Supercharger Division of The Christensen Machine Company, 100 Fourth St., Racine, Wis.

Designers! Whether you figure



Adjusting Knob for Room Thermostat

Cost/M Brass $16.10
Aluminum . . . 9.44

Savings Based On 1000 Parts*

41.3% **$6.66**

Cover Screw for "Protecto Relay" Unit

Cost/M Brass $16.80
Aluminum . . . 10.80

Savings Based On 1000 Parts*

35.7% **$6.00**

Tension Nut for "Immersion Aquastat"

Cost/M Brass $9.10
Aluminum . . . 4.50

Savings Based On 1000 Parts*

50.5% **$4.60**

Adjusting Screw for "Immersion Aquastat"

Cost/M Brass $11.90
Aluminum . . . 7.33

Savings Based On 1000 Parts*

38.5% **$4.57**

Packing Nut for Temperature Controller Unit

Cost/M Brass $33.60
Aluminum . . . 21.45

Savings Based On 1000 Parts*

36.2% **$12.15**

NOTE: Tooling costs and machining times are comparable for both brass and aluminum

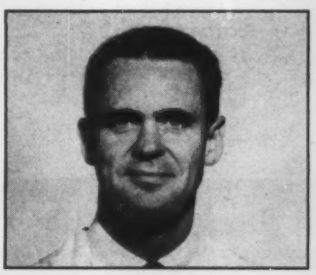
savings in per cents or dollars,

conversion from brass to aluminum screw machine parts adds up to real economy! For example, these five conversions saved Minneapolis-Honeywell Regulator Company 36.7 to 50.5 per cent per part . . . or a total of $7,720* a year! All five parts run at maximum efficient speed on present machines with little or no change in tooling or equipment . . . why not let a Kaiser Aluminum engineer help you get savings like these in

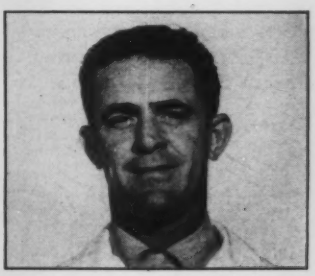
Kaiser Aluminum

For complete information and expert assistance, call one of our many distributors, or look for our local number in your classified telephone directory.
Kaiser Aluminum & Chemical Sales, Inc., *General Sales Office,* Palmolive Bldg., Chicago 11, Ill.; *Executive Office,* Kaiser Bldg., Oakland 12, Calif.

Recommended by Managements



Specified by Designers



Preferred by Operators

***Savings based on metal prices current when the conversion was made.**

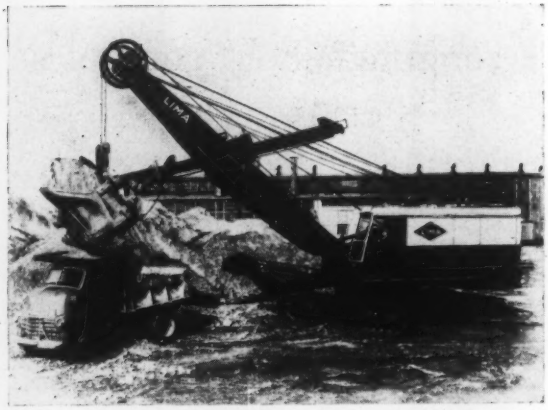
Circle 452 on page 19

A new **JEFFREY CHAIN** for a new **Lima** Shovel

INTRODUCED at the 1957 Road Show, this Baldwin-Lima-Hamilton 3-yard shovel got lots of well-earned attention. It's a husky giant with many unusual features. For example, it can be knocked down into units of less than 60,000 pounds for easy haulage.

Less unusual is the fact that the main drive is through Jeffrey chain. A new design, to be sure, to suit the needs of this new shovel, but Jeffrey chain is standard on many Lima crawler drives—proved dependable for this gruelling, demanding service.

Jeffrey makes chain, attachments, sprockets and accessories in types and sizes to meet every service requirement—for power transmission and conveying. Standard components are carried in stock for your convenience at handy locations. The Jeffrey Manufacturing Company, 798 North Fourth Street, Columbus 16, Ohio.

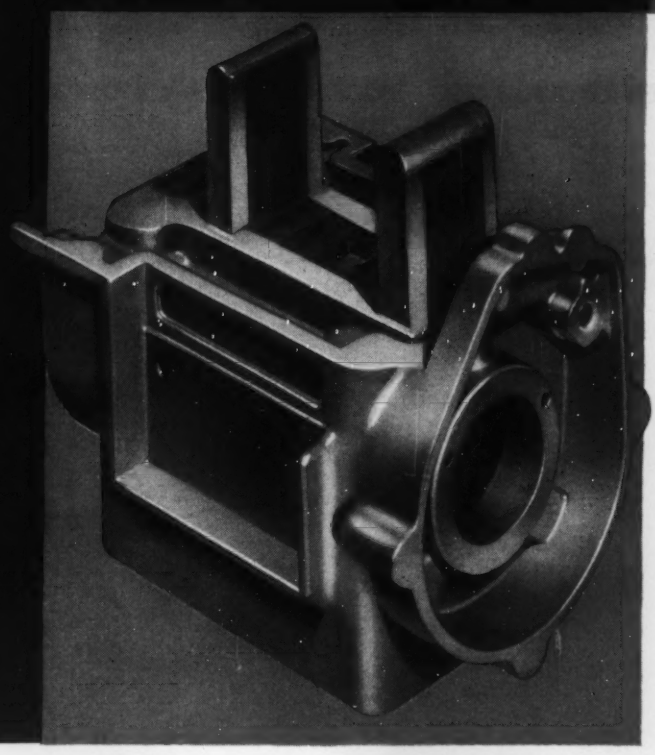


It takes husky chain to transmit the horsepower for this shovel's main drive.

JEFFREY

CONVEYING · PROCESSING · MINING EQUIPMENT . . . TRANSMISSION MACHINERY . . . CONTRACT MANUFACTURING

Circle 453 on page 19



Problem: To produce a rugged, one-piece, weatherproof magneto frame for International Harvester farm tractors. Five separate magneto parts must be incorporated into the body of the casting, and accurately positioned to meet exacting tolerances of the final assembly. Must be designed for fast, economical production.

Solution: Working closely with IHC, Stewart Die Casting engineers developed a "slide die" consisting of an elaborate system of cores, slides and positioners. This intricate arrangement holds the two magnetic field pieces, the two magnetic pole pieces, and the bearing race in exact position while the metal is injected around them in the die. The result was a precision casting that can be produced economically with a minimum of rejects, and give dependable performance under all conditions.

Stewart found the solution and made delivery on time!

This is just one of many complicated die castings that Stewart has developed promptly . . . and produced in quantity *at low cost.*

Nearly half a century of experience, plus unexcelled production facilities, enables Stewart to offer fast, practical solutions to any die casting problem.

Whatever type of die casting you need— large or small, simple or intricate — you can count on Stewart for a quality job . . . delivered on schedule!

Stewart DIE CASTING
Division of STEWART-WARNER CORPORATION
Chicago, Illinois: 4535 Fullerton Avenue • Bridgeport, Connecticut: 275 Warren Street

46 YEARS OF SERVICE TO INDUSTRY

Circle 454 on page 19

NEW FACTS

SEE WHAT WARNER'S NEW POWER-

• More than a catalog—it's the complete, fully illustrated story of Warner's newest electric brake designed for fail-safe applications. For example, the pages illustrated below explain the unique operating principle of Power-Safe brakes . . . how they give you *both* full-time reserve holding power and fast, pushbutton or automatic power braking . . . show how with fewer parts these electromagnetic units give you more safety and control features . . . more torque for their size and weight than any other fail-safe brake on the market.

• How to make your product safer and more automatic . . . and how to "design in" assurance against high service costs—these are just a few of the advantages of Power-Safe braking, explained and illustrated in the pages shown below. Get your free copy and check these outstanding features, including stepless torque modulation and a fail-safe mechanism that has no springs or moving parts—it's a brake that delivers constant torque and dependable operation throughout its service life.

36-PAGE TECHNICAL REPORT

Just off the press, and it's yours free—all the information you need to start engineering powerful new sales features into your machinery. Your introduction to numerous startling advantages of electric fail-safe brakes—it's an authoritative 36-page illustrated report for design engineers who are ready for newer and better ways of controlling power and motion. Includes photographs, drawings, diagrams, and complete explanation of operation, selection factors, torque characteristics, features, and controls. With operating costs mounting every day, your customers need the advantages Power-Safe brakes make possible.

about fail-safe braking!

SAFE BRAKE CAN DO FOR YOU!

• How to equip your product with advanced power transmission principles now made possible by the fail-safe brake that is easy to install, using a variety of electric controls and standard power transmission components . . . how minimum redesign produces the maximum addition of operating features that boost efficiency and build customer satisfaction. Details for selecting the proper Power-Safe brake are outlined on the pages below—learn how easily and quickly you can make decided improvements in your product and beat competition by installing this new type of brake.

• Two types of Power-Safe electric brakes meet all fail-safe requirements. Warner's Model "PER" actually gives you *two* electric brakes in one—combines fail-safe braking capacities up to 30 hp, with electromagnetic power braking capacities up to 100 hp. Electrically released ("ER") brakes do not have the power braking feature, but operate quickly and positively in the event of a power failure, stopping the load without shock and holding it until the magnet is energized. Four standard sizes are rated up to 40 hp.

WARNER

Pioneers of

ELECTRIC BRAKES & CLUTCHES

WARNER ELECTRIC BRAKE & CLUTCH CO.
Beloit, Wisconsin

SEND for your free copy of Warner's new Power-Safe Technical Report

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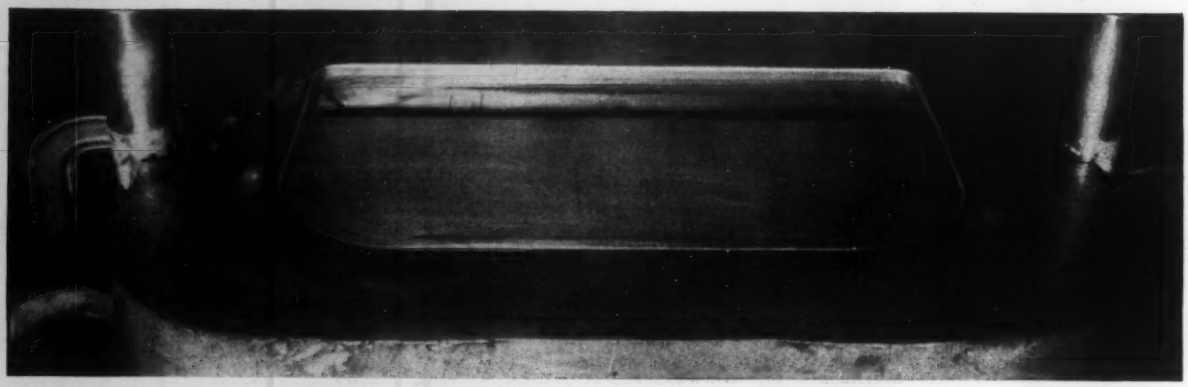
Circle 455 on page 19

AFTER FORMING 10,000 STAINLESS STEEL SHEETS THIS DUCTILE CAST IRON DIE SHOWS...



Ductile Cast Iron Die (flame-hardened) used to draw and form stainless steel sheets for inside and outside parts of milk and cream dispensers. Its strength and toughness give it good die characteristics. "Built-in-lubrication" — supplied by spheroids of graphite — resists galling and pickup, keeps critical surfaces smooth and blemish-free. Dies cast by Prospect Foundry Company for Norris Dispensers, Inc., Minneapolis, Minn. For full particulars on the use of Ductile Cast Iron for stamping and drawing carbon steel, stainless steel or aluminum, just write us.

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ductile iron...the cast iron that can be twisted and bent.

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(Advertisement)

Helpful Data from DE LAVAL

How to calculate the efficiency of worm gearing

The efficiency of worm gearing is determined by frictional losses at the tooth contact, bearings and oil seals plus losses from oil churning and windage. A formula for efficiency at the tooth contact may be developed from a consideration of the forces at the contact. Figure 1 shows these forces acting on a developed section of the worm thread. For simplicity the pressure angle has been assumed to be zero.

The coefficient of friction of the worm and gear is a function of the materials, finish, lubrication and rubbing speed. The latter is the relative speed between a point on the pitch surface of the gear and one on the pitch surface of the worm. The coefficient of friction varies very little at high rubbing speeds but rises with increasing rapidity as the speed drops below 500 fpm.

The efficiency formula developed in Figure 1 involves worm lead angle and the friction angle. Figure 2 provides a relationship between friction angle and rubbing speed based on tests made on accurately manufactured gearing consisting of hardened and ground worm and bronze gear operating in oil.

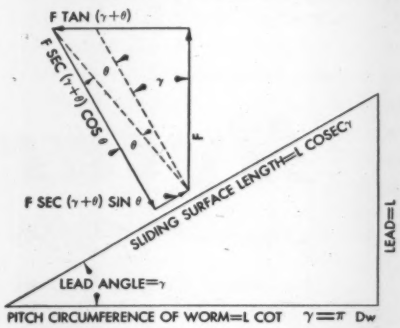
The formula for rubbing speed is:

$$V = \frac{.262\ Dw \times \eta}{\cos \gamma}$$

where

$V =$ Rubbing speed – feet per minute
$Dw =$ Worm pitch diameter – inches
$\eta =$ Worm speed – rpm
$\gamma =$ Worm lead angle

FIGURE 1.
Development of equation for efficiency at contact between worm and gear



F=TANGENTIAL FORCE ACTING ON GEAR

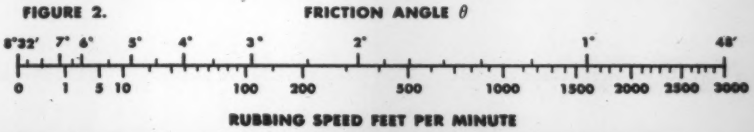
F TAN ($\gamma + \theta$) = TANGENTIAL FORCE APPLIED TO WORM

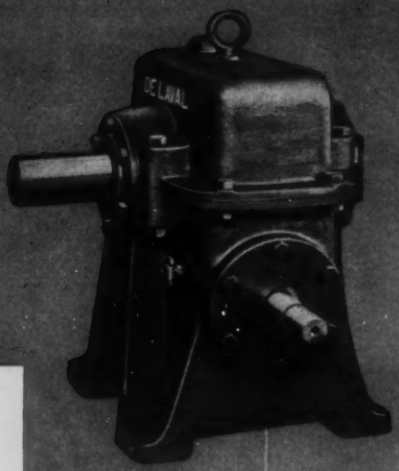
F SEC ($\gamma + \theta$) COS θ = FORCE NORMAL TO CONTACT SURFACE

F SEC ($\gamma + \theta$) SIN θ = FRICTIONAL FORCE

$$\text{EFFICIENCY} = \frac{\text{WORK REALIZED}}{\text{WORK APPLIED}} = \frac{L \times F}{L \cot \gamma \times F \tan (\gamma+\theta)} = \frac{\tan \gamma}{\tan (\gamma+\theta)}$$

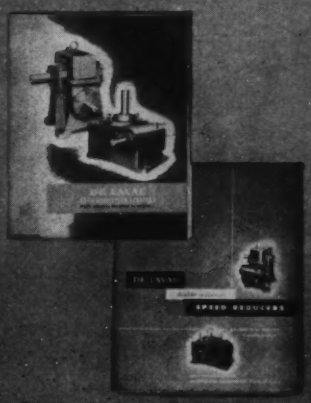
FIGURE 2.





DE LAVAL Worm Gear Speed Reducers Offer Efficiencies to 96%

Ruggedly built for long efficient service De Laval speed reducers are made in horizontal and vertical single reduction units in ratios of 3:1 to 100:1. They are also available in double horizontal and vertical double reduction units as well as in helical-worm and double-worm design. Ratios from 37.8:1 up to 6400:1.



Write for your copies of Catalogs G-WBV and G-WWH to De Laval Steam Turbine Company, 858 Nottingham Way, Trenton 2, New Jersey

Please direct inquiries to advertiser, mentioning MACHINE DESIGN

Another new development using

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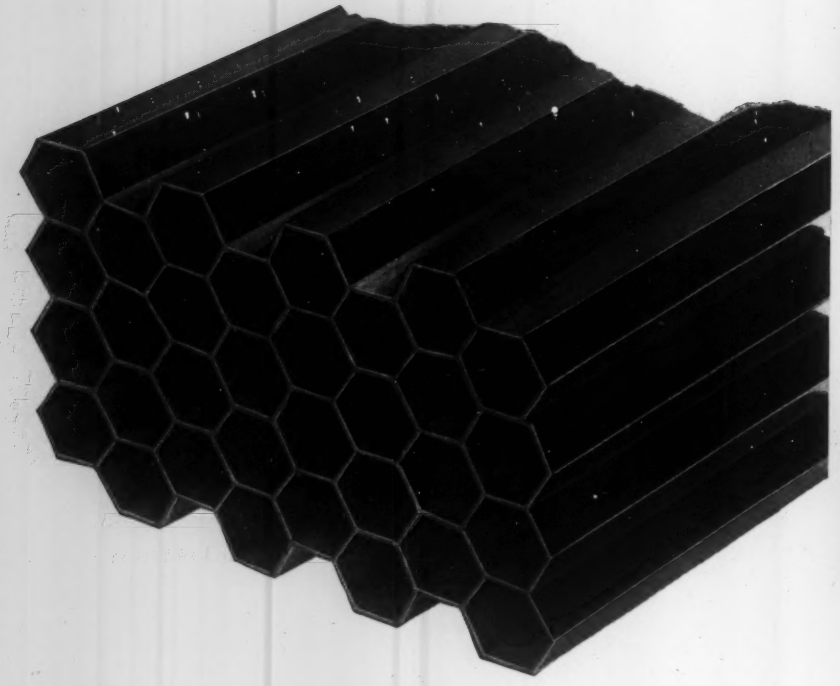
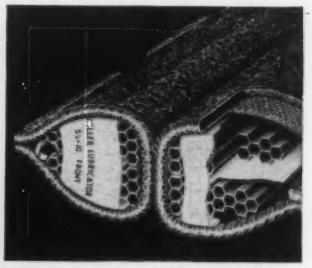
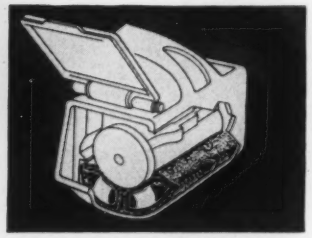




Lubricator for freight car journal boxes manufactured by Miller Lubricator Company, Winona, Minn. Hycar rubber is used in honeycomb spring core. Hycar latex is used as anchor for pad threads.



Cutaway drawing showing journal box application of lubricator pad that stops "hot boxes". Resilient Hycar core permits easy pad installation, assures uniform pad-journal contact and withstands oil immersion.

First honeycomb extrusion of rubber made possible by Hycar

THROUGH imaginative die engineering and the use of Hycar nitrile rubber, Miller Lubricator Company has developed a technique for producing low-cost multiple-extrusions of rubber honeycombs.

These unique Hycar honeycomb cores have outstanding physical and chemical properties. They have exceptional radial spring, axial stiffness and stability of shape and dimension. They withstand temperature extremes and oil immersion and are resistant to abrasion, gas and many chemicals.

With these properties in the Hycar honeycomb at their disposal, Miller Lubricator has put them to use in their freight car journal box lubricators. In this application, the Hycar honeycomb extrusions live in oil and act as a spring support for fiber pads which lubricate the journal bearings.

Learn more about Hycar—it may help *you* design new products or improve the ones you already make.

For information on Hycar, write Dept. HK4, B.F.Goodrich Chemical Company, 3135 Euclid Avenue, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

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B.F.Goodrich GEON polyvinyl materials • HYCAR American rubber and latex • GOOD-RITE chemicals and plasticizers • HARMON colors

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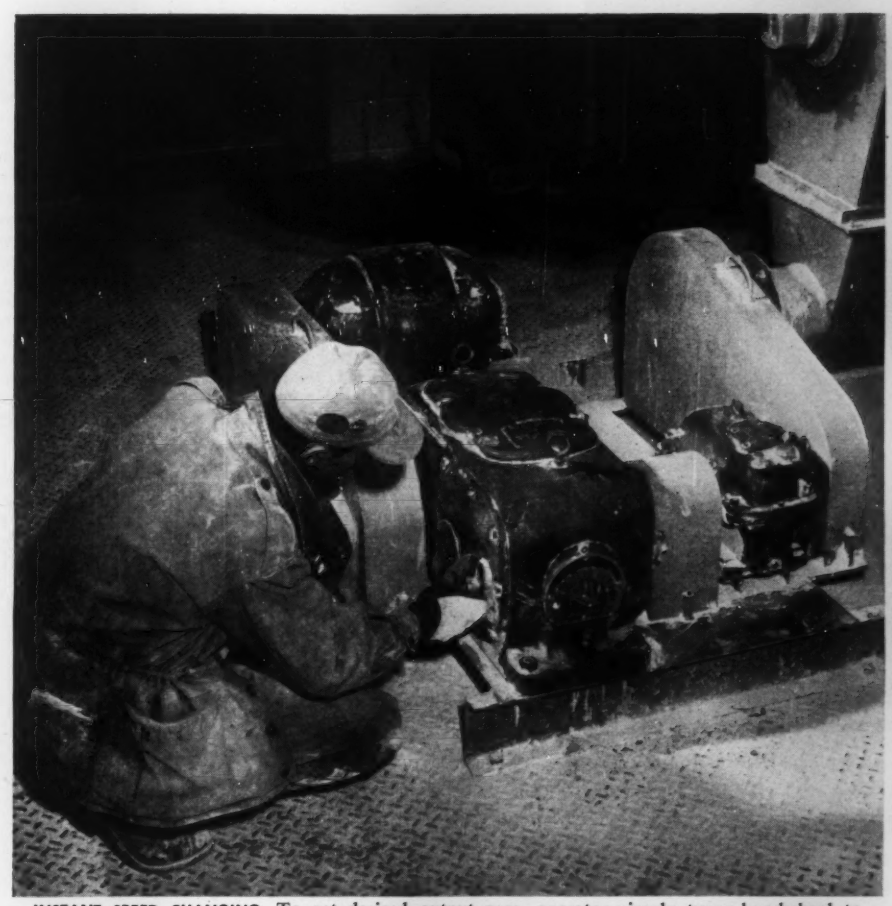
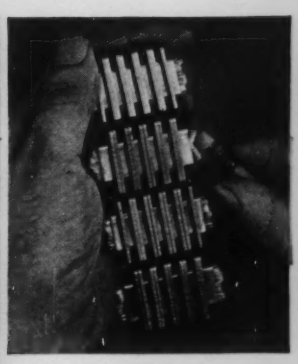
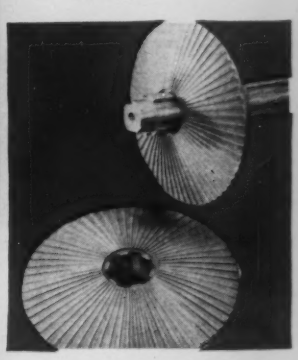


INSTANT SPEED CHANGING. To get desired output rpm, operator simply turns handwheel to desired position on easy-to-read dial. P.I.V. responds instantly, accurately. Drives are also available with automatic, electric, pneumatic or hydraulic controls.



SELF TOOTH-FORMING CHAIN consists of a series of steel laminations, serving as teeth, which are free to move from side to side, either singly or collectively.



RADIALLY GROOVED WHEELS have teeth cut at constant depth but of increasing width toward wheel periphery. Beveled sides of teeth provide gripping surfaces for chain.

Slipless transmission - - stepless selection

That's because LINK-BELT P.I.V. uses self-tooth-forming chain

LINK-BELT P.I.V.—unlike other variable speed drives—incorporates an exclusive metal, self-tooth-forming chain to give you instant, positive speed variation, regardless of load. This unique drive permits infinitely variable speed changes without loss of accuracy or interruption of operations. That's why P.I.V. is all industry's choice for jobs requiring stepless, slipless power transmission.

Changing speed is simple too. A turn of the control screw simultaneously varies the effective diameters of two sets of conically shaped wheels—closing one set, spreading the other. At the same time, the self tooth-forming chain automatically adjusts to provide desired ratio between the input and output shafts.

Link-Belt P.I.V drives are fully enclosed for trouble-free operation. They're splash-lubricated for long life—unaffected by atmospheric conditions. Choose from 8 sizes in 16 standard types, with the aid of Book 2274. Call your nearby Link-Belt office for complete information.

14.314 A

LINK-BELT P.I.V. VARIABLE SPEED DRIVE

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville (Sydney), N.S.W.; South Africa, Springs. Representatives Throughout the World.

Circle 458 on page 19

INCREASES CORROSION RESISTANCE. The huge rotor illustrated here is the main structural component of a Ljungstrom Horizontal Air Preheater. Three of these units, designed to serve a 1,900,000 pounds-per-hour-capacity boiler, are among the largest ever manufactured by The Air Preheater Corporation, New York. Each complete preheater weighs 270 tons. The rotor itself—25′2″ in diameter and 10′10½″ deep—when fully loaded with the heating element, weighs about 390,000 lbs.

Because sulfur in the gases combines with moisture—sulfuric acid is formed when the temperature drops below the dew point at the "cold" end of the rotor—corrosive action can be highly severe in this area. Corrosion means maintenance.

Aiming at a reduction in maintenance, the manufacturer cooperated with the U. S. Bureau of Mines in exhaustive tests to determine the corrosion resistance of various materials under sulfuric acid attack in air preheaters. These tests, made over a 5½-year period, showed that the corrosion rate of low-alloy USS COR-TEN Steel was *lower* than all but one of the *high* alloy steels tested, was less than one-half that of carbon steel and less than one-fourth that of cast iron.

As a consequence, USS COR-TEN Steel is specified for the cold end heating elements and containing baskets on all conventional boiler applications. Where unusually severe corrosion is anticipated, USS COR-TEN Steel is also specified in all or part of the rotor including diaphragm plates, bar stock, rim angle and filler plates.

INCREASES DURABILITY, REDUCES COST. Tote boxes have to take quite a beating. Used for handling, storing and shipping automotive and other parts, they must be able to withstand plenty of rough treatment.

That's why the "Hamlintainer" shown here—a *collapsible* tote box that sets up and folds flat in less than 20 seconds—is now built entirely of USS COR-TEN Steel. COR-TEN Steel's greater strength, 50% higher than carbon steel, makes it possible to build the "Hamlintainer" up to 100 lbs. lighter than carbon steel units, yet so strong and rigid that it will withstand long and rugged service and is not susceptible to bending and distortion. The fact that the COR-TEN Steel ends and sides have the stamina needed to permanently maintain their shape is of utmost importance. It means that throughout its long life the box will always be easy to set up, fold and stack flat.

As compared to the metal construction used in an earlier design, USS COR-TEN Steel makes the "Hamlintainer" not only stronger, more rigid and more durable but also less costly to produce, according to the manufacturer, Hamlin Metal Products Co., Akron, Ohio.

1933 UNITED STATES STEEL USS HIGH STRENGTH STEELS 1957

24 YEARS OF PERFORMANCE

High-strength USS COR-TEN Steel pays off in equipment like this

What does your product need to make it better? Greater durability? Bigger capacity? Cheaper maintenance? Lower operating cost?

Do you want to make it stronger, lighter in weight, more corrosion resistant, better able to withstand abrasion, impact and fatigue?

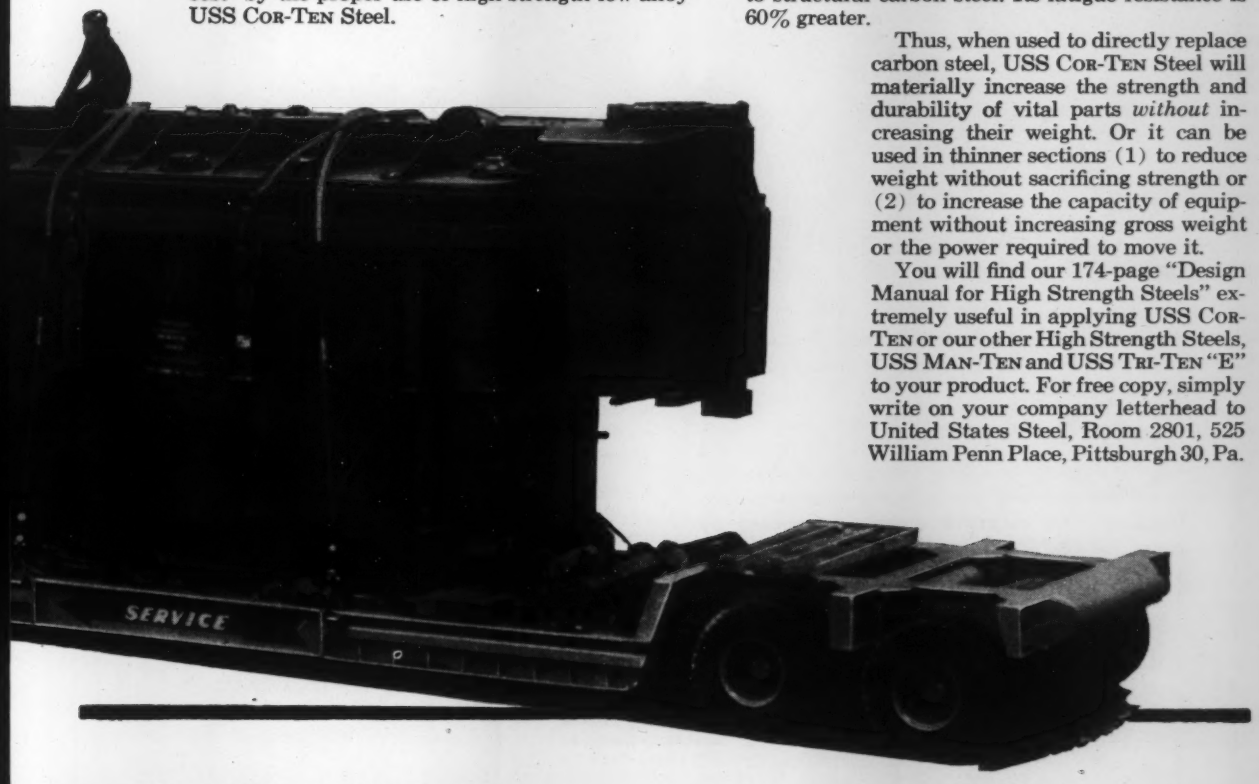
You can obtain any or all of these important money-saving benefits—at little or no increase in cost—by the proper use of high-strength low-alloy USS COR-TEN Steel.

USS COR-TEN Steel is distinguished by its superior resistance to atmospheric corrosion—4 to 6 times that of carbon steel, 2 to 3 times that of copper steel.

In thickness of ½" and under, COR-TEN Steel has a minimum yield point of 50,000 psi and a minimum tensile strength of 70,000 psi. In resistance to abrasion, shock and impact, it is superior to structural carbon steel. Its fatigue resistance is 60% greater.

Thus, when used to directly replace carbon steel, USS COR-TEN Steel will materially increase the strength and durability of vital parts *without* increasing their weight. Or it can be used in thinner sections (1) to reduce weight without sacrificing strength or (2) to increase the capacity of equipment without increasing gross weight or the power required to move it.

You will find our 174-page "Design Manual for High Strength Steels" extremely useful in applying USS COR-TEN or our other High Strength Steels, USS MAN-TEN and USS TRI-TEN "E" to your product. For free copy, simply write on your company letterhead to United States Steel, Room 2801, 525 William Penn Place, Pittsburgh 30, Pa.



INCREASES STRENGTH, SAVES WEIGHT. Shown here hauling a 117-ton transformer, this 150-ton-capacity trailer—built by Columbia Trailer Company, Vancouver, B. C., for the Arrow Transfer Company of that city—is the largest trailer ever built in Canada.

This 80-ft.-long trailer is constructed almost entirely of USS COR-TEN Steel. It is about 25% lighter than if it had been built of structural carbon steel. Specifically designed for handling transformers of giant size, it has a depressed center deck which makes loading and unloading easier and keeps center of gravity low to prevent danger of upset.

Says the manufacturer: "We have found that when a trailer is made from structural carbon steel there is a greater possibility that it can be permanently damaged from overloading than in the case of a similar unit made from high strength steels. That's why, in designing trailers of this type, we always use USS COR-TEN Steel. This construction gives us the high strength needed, plus excellent corrosion resistance and freedom from excess weight—all very important in equipment like this."

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USS HIGH STRENGTH STEELS

USS MAN-TEN · USS COR-TEN · USS TRI-TEN

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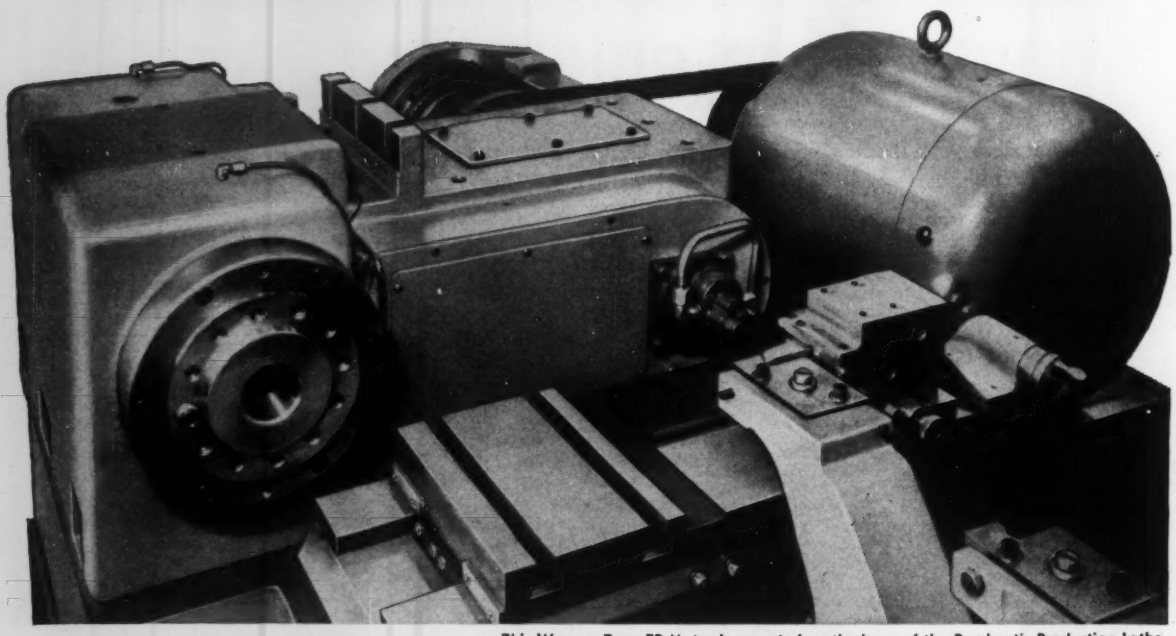
UNITED STATES STEEL

WAGNER ELECTRIC MOTORS...THE CHOICE OF LEADERS IN INDUSTRY

WAGNER MOTORS mean less down-time for production machinery



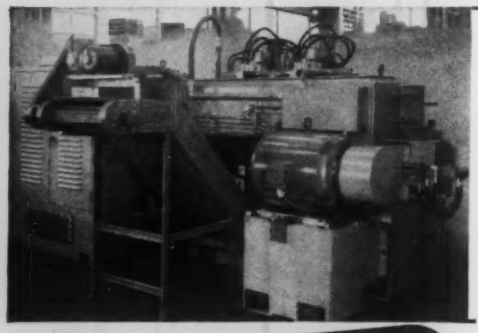
This Wagner Type EP Motor is mounted on the base of the Reedmatic Production Lathe.

Wagner totally-enclosed fan-cooled motors will give your machine tools the drives they need to give continuous service.

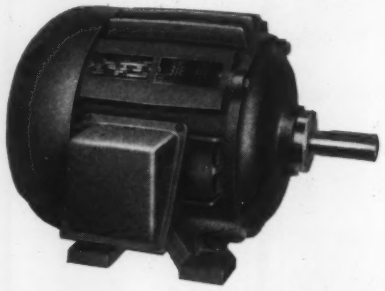
THEY ASSURE LESS DOWN TIME. Wagner totally-enclosed fan-cooled motors are *fully* protected against damage from steel filings, chips, dust, dirt, fumes and moisture. This built-in protection assures freedom from excessive down time caused by motor failure.

THEY REDUCE MAINTENANCE COSTS. Wagner totally-enclosed motors require no maintenance other than periodic lubrication. These motors are designed to run cooler and longer between maintenance periods, but when greasing is necessary, readily accessible lubrication openings permit addition of grease or a complete relubrication.

A Wagner field engineer will be glad to help you design non-stop performance into your production machinery by recommending the motors that best fit your specific needs. Just call the nearest of our 32 branch offices.



This Reed-Prentice tracer controlled automatic production lathe, which turns automobile axles in 30 seconds, is equipped with Wagner Type EP totally-enclosed fan-cooled Motors. These motors are fully described in Bulletin MU-203. Write for your file copy today.



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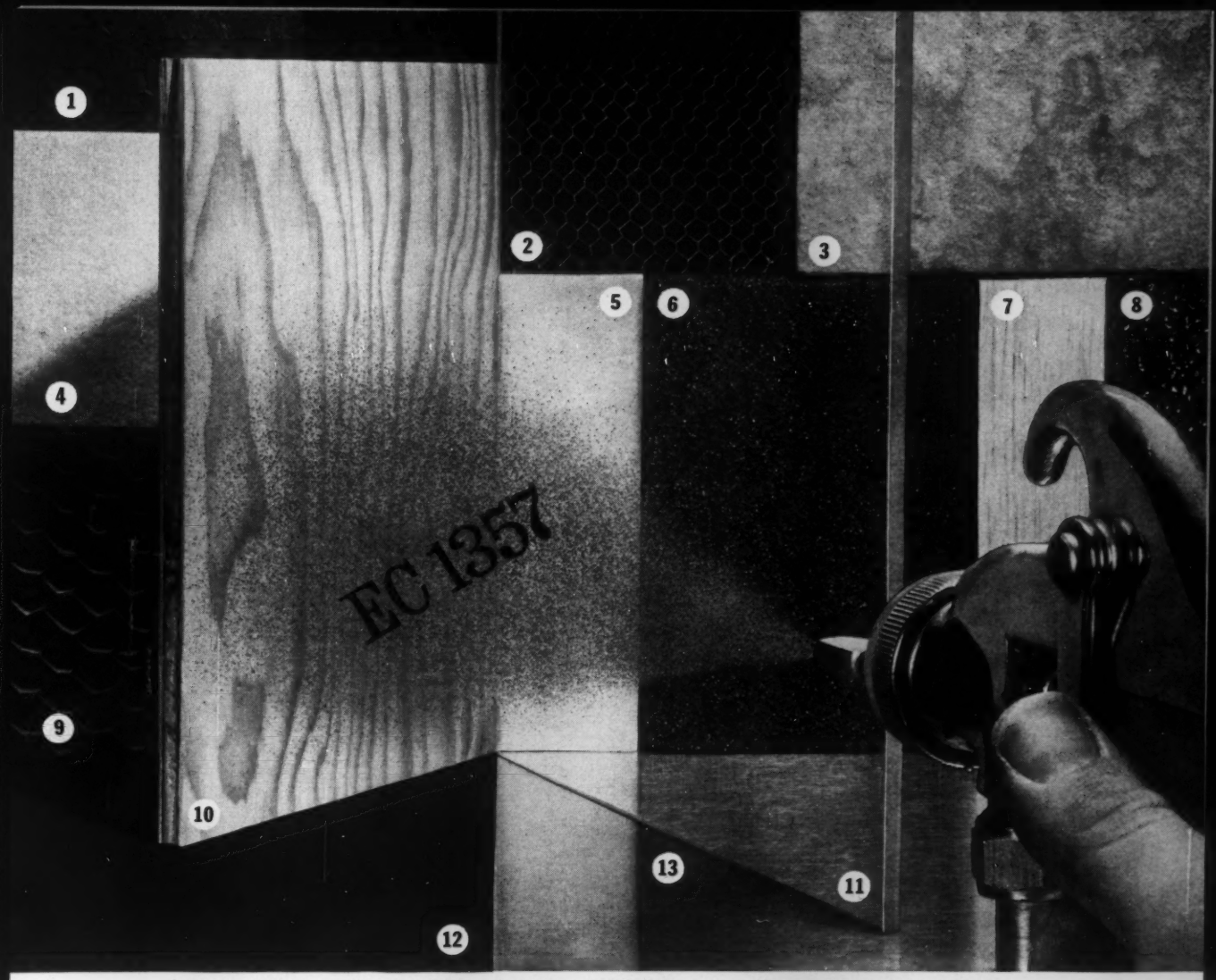

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. . . just one adhesive bonds all kinds of sandwich materials!

You name the core and skin materials . . . just one versatile adhesive, EC-1357, will make non-load-bearing sandwich panels of them all!

For instance, cores of cellular or fibrous glass, wood, honeycombs of aluminum, paper or steel; skins of steel, plywood, glass, porcelainized metal, hardboard, aluminum, to name a few.

The union you get has great strength which increases as production continues, and resists moisture, high and low temperatures, weathering. For maximum immediate bond strength, EC-1357 may be force-dried through infrared exposure; or it can be dried at room temperature. All you need is a nip roller or cold press to bond sprayed surfaces. You save time and money. For load-bearing uses, look into 3M Adhesive EC-1177.

SEE WHAT EC-1357 BY 3M CAN DO FOR YOU! Consult 3M research. Contact your 3M Field Engineer. Or for information and free literature, write on your company letterhead to: 3M, Dept. 108, 417 Piquette Ave., Detroit 2, Michigan.

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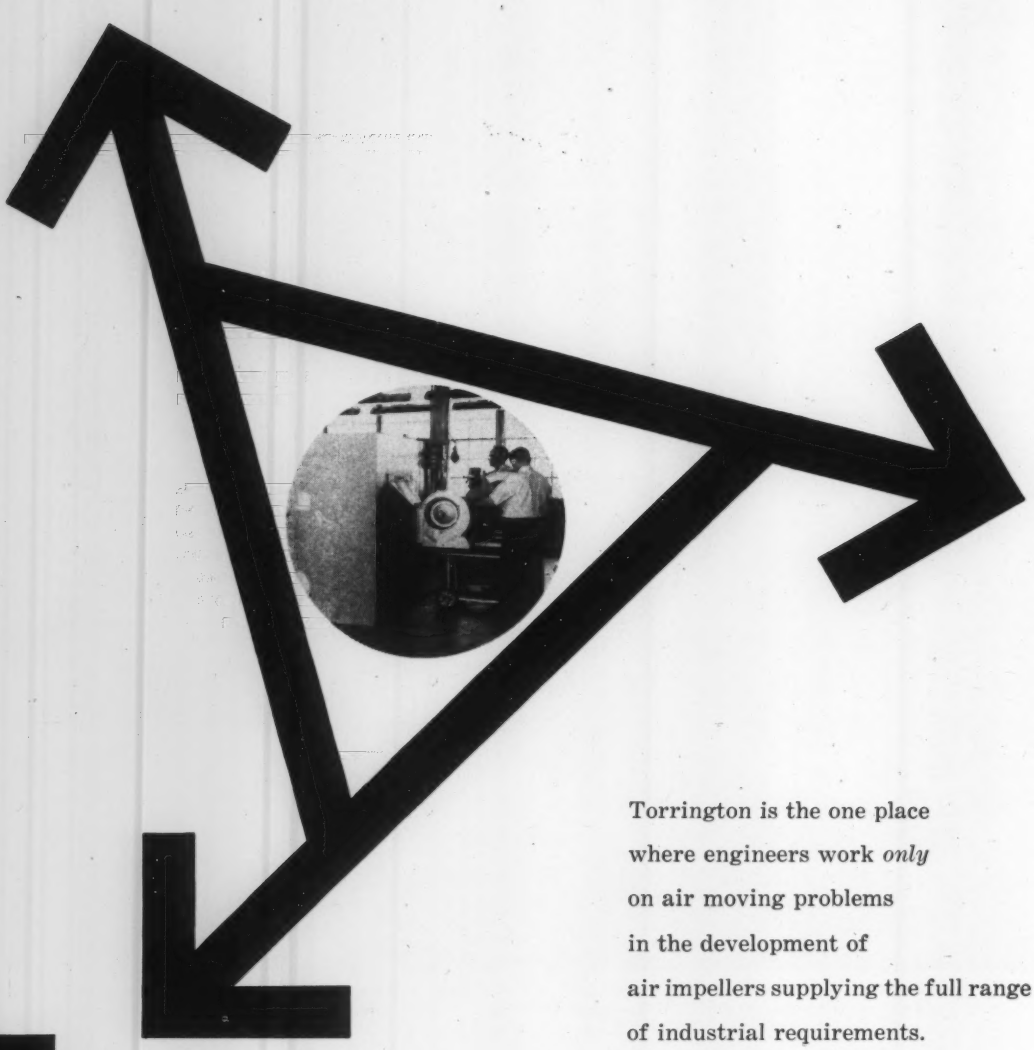

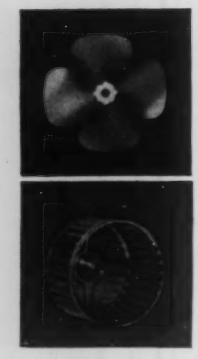

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Torrington is the one place
where engineers work *only*
on air moving problems
in the development of
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of industrial requirements.
As a result, more air moving
problems are being studied today
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If you have product problems
relating to the design, application
and performance of air impellers,
talk to Torrington.

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Circle 462 on page 19

WEBSTER'S NEW PILOT OPERATED RELIEF VALVE

Compact design adapts to "tight" installations. Adjustable from 200 to 2000 psi. Maximum capacity, 20 gpm.

BOOSTS WORK OUTPUT 38.5%!

call the man from Webster

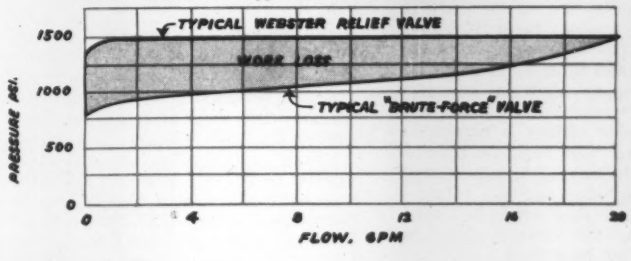
His intimate knowledge of this new relief valve — its many benefits and applications — can help in adapting it to your product.

Full speed power up to 93% of relief setting is now possible with this new Webster pilot operated relief valve. Result: 38.5% work bonus over "brute-force" type valves! More, you get all the benefits of clog-free performance, quieter operation...lower price. Mighty sound reasons for specifying Webster's pilot operated relief valve *now*.

OIL HYDRAULICS DIVISION

WEBSTER ELECTRIC
MELROSE 5-3511
RACINE · WIS

Typical performance curve shows minimum pressure drop and instantaneous response of Webster pilot operated relief valve over "brute-force" type. 38.5% work bonus!



☐ *Have THE MAN FROM WEBSTER contact us—*

—Please send the following:

☐ *Bulletin H3A2 covering the new Webster pilot operated relief valve*

☐ *Complete hydraulic catalog of pumps, valves and fluid motors*

☐ *New information or data as published*

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LATEST PROPERTY AND APPLICATION DATA ON THESE VERSATILE ENGINEERING MATERIALS

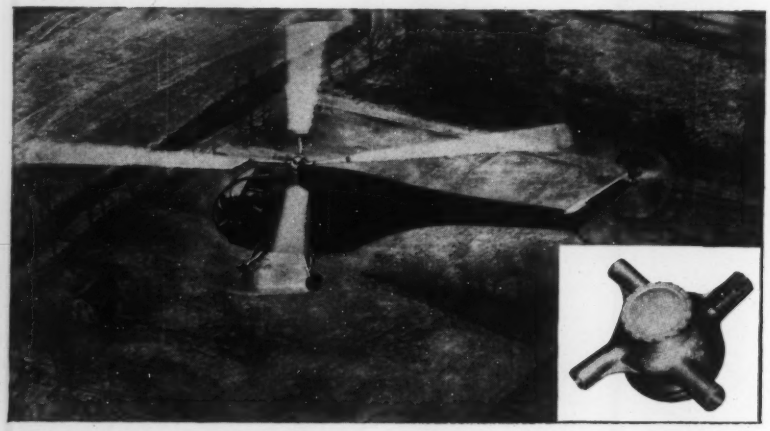
Tough, wear-resistant bearings of ZYTEL® nylon resin outperform conventional materials in helicopter rotor

"This application has solved all spar-tube galling problems," reports the Rotor Group Engineer at Doman Helicopters, Inc. "By eliminating galling problems in the Doman Rotor, there is no longer a need for field maintenance of the blade-retention system."

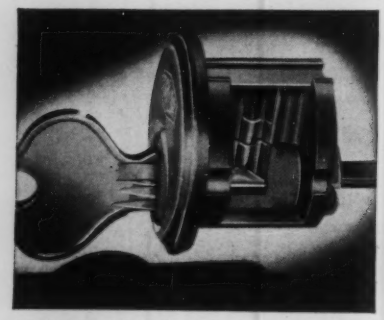
The application: a liner of ZYTEL nylon resin in the main rotor-blade bearing packs which support spar tubes in the arm of the rotor hub. The use of ZYTEL solved a problem of fretting corrosion which destroyed other sleeve bearings.

The excellent bearing characteristics and toughness of ZYTEL solved this engineering design problem. Other desirable mechanical properties include ease of fabrication by molding or machining from stock, strength in thin sections and resistance to impact.

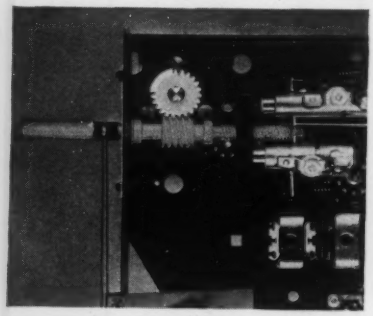
Many uses of ZYTEL are based also on its good electrical insulating properties. ZYTEL nylon resin is rated for intermittent operation up to 250°F.; for continuous operation at such elevated temperatures, heat-stabilized grades are available. ZYTEL resists the action of many common chemicals. Because of the low-friction characteristics and resiliency of ZYTEL nylon resin, gears, cams and bearings operate quietly, with little or no lubrication. Complicated shapes can be molded to precise dimensions around inserts.



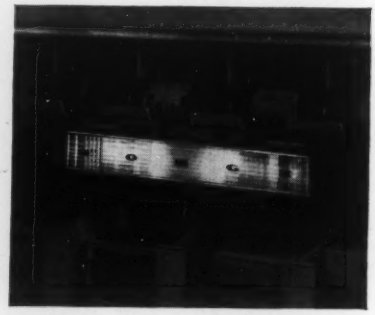
SLEEVE BEARING of ZYTEL supports spar tube in the arm of helicopter rotor hub. Bearing is 2" in diameter, 6" in length. Toughness of ZYTEL enables it to outperform other bearings. Spar-tube life is extended, maintenance reduced. (Made by Doman Helicopters, Inc., Danbury, Connecticut.)



CYLINDER PLUG for door lock is molded of Du Pont ZYTEL nylon resin. Cylinder lubrication is not necessary because of the low coefficient of friction of ZYTEL. The cylinder plug does not stick and turns smoothly in the lock. Unlike certain metals, the cylinder plug is corrosion-resistant and weatherproof and is not subject to electrolytic action. The hardness, durability and the abrasion resistance of ZYTEL nylon resin help insure against wear, and provide long service life for all parts molded of ZYTEL. (Door lock manufactured by The Taylor Lock Company, Philadelphia, Pennsylvania.)



INTRICATE TUNING SHAFT for radio selector mechanism is precision-molded of ZYTEL nylon resin. The shaft needs no lubrication yet operates easily. It is nonmagnetic and has high electrical resistance. Stiffness and torsional strength are more than adequate. Shaft has integrally molded gears, washers, holes, bevel and step. Considerable savings in fabrication costs over metal were realized. Components of ZYTEL nylon resin usually need no further finishing after molding. (Molded by Engineered Nylon Products, South Bend, Indiana, for Granco Products, Long Island City, New York.)



ILLUMINATOR LENS made of Du Pont LUCITE® acrylic resin distributes soft, even light throughout the interior of the new Norge Home Freezer. Located in the door, the lens also serves as an attractive name plate. Du Pont LUCITE is strong and tough . . . has remarkable optical properties, transmitting 92% of impinging light. LUCITE has high resistance to shattering . . . good dimensional stability. (The LUCITE lenses shown above molded by Stimsonite, Division of Elastic Stop Nut Corporation of America, Chicago, Illinois; Freezer by Norge Sales Corporation, Chicago, Illinois.)

ENGINEERING NEWS

ZYTEL®, TEFLON®, LUCITE®

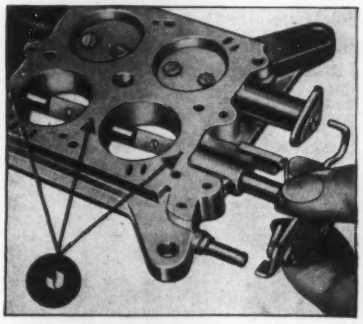
Thin-walled tubing of TEFLON® resins withstand soldering temperature, simplify assembly

TEFLON tetrafluoroethylene resins maintain high dielectric strength at elevated temperatures. They also have high surface resistivity, dropping only to 10^{13} ohms at 100% relative humidity. TEFLON maintains full electrical insulating characteristics, even when flexed or bent during assembly and installation. This combination makes it possible to miniaturize an electrical assembly without fear of dielectric failure.

For example, thin-wall tubing of a TEFLON resin simplifies assembly of component parts in a series of miniature rotary tap switches. Since TEFLON resins will not burn, melt or decompose when connections next to them are soldered, assembly of switch parts is easier, faster, and the possibility of accidental grounding is minimized. The thermal stability of TEFLON resins, even in thin sections, is demonstrated in this tubing where the wall thickness is only .014". The nominal inside diameter is .075". TEFLON resins meet Class H, AIEE standards for maximum insulating temperatures.

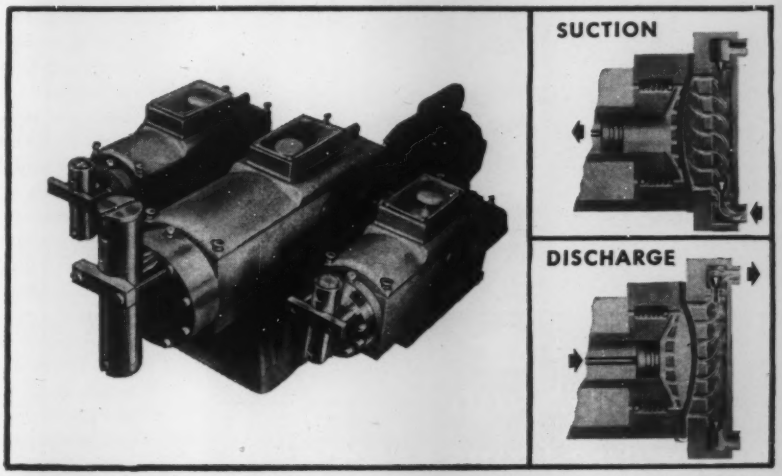
TEFLON resins are non-flammable, have good mechanical strength and are completely unaffected by sunlight or outdoor weathering. They have zero water absorption by ASTM test D570-42, resist corrosion and growth of fungus, are chemically inert.

Carburetor bearing problem solved with TEFLON® resins



Carburetor bearings of a TEFLON resin are used on the secondary throttle shaft of carburetors in all 1957 models of two popular cars. "Self-lubricating" property of TEFLON eliminated a serious problem of slip-stick action of the shaft caused by gums in gasoline. The use of carburetor bearings of TEFLON eliminated the necessity for chrome-plating the shafts. Top product performance is assured, at decreased manufacturing costs. (Carburetor by Holley Carburetor Company, Van Dyke, Michigan; bearings by Modern Industrial Plastics, Inc., Dayton, Ohio.)

Chemical inertness, high flex strength of TEFLON® resins are featured in pumps handling powerful corrosives



"PULSAFEEDER" DIAPHRAGM PUMP employs a tough, flexible diaphragm of a chemically inert TEFLON tetrafluoroethylene resin. Model shown is a triplex assembly used in handling hydrogen peroxide, sodium hydroxide and sodium silicate for bleaching fabrics. (Flexible diaphragm of TEFLON trademarked Fluorlastic by the Joclin Manufacturing Company, Wallingford, Connecticut; pump by Lapp Process Equipment Division of the Lapp Insulator Company, Inc., Leroy 6, New York.)

The Lapp "Pulsafeeder" can be used as a metering pump or as a proportioner, pumping two or more liquids in an established ratio. In the case of highly corrosive fluids, it depends on tough, flexible diaphragms of a TEFLON tetrafluoroethylene resin for resistance to chemical attack plus high strength.

On the piston side of the diaphragm, TEFLON tetrafluoroethylene resins are unaffected by any type of oil used as the hydraulic activating medium. On the pumpage side, TEFLON resins are completely inert to acids, aliphatics, aromatics, chlorinated hydrocarbons, alkalies and, in fact, almost any chemical or solvent in commercial use. The few exceptions to this include attack by the alkali metals under certain conditions. At high temperatures and pressures, halogens and certain halogenated chemicals and solvents may also affect TEFLON. TEFLON is rated for use to 500°F. and does not become brittle even at temperatures near absolute zero.

TEFLON 1, TEFLON 5 and TEFLON 6 resins may be used to make durable components such as seals, gaskets, packings and bearings. They are superb dielectrics.

The properties of TEFLON resins may have application in one of your own designs. Mail the coupon for a full report on uses and characteristics.

SEND FOR INFORMATION

For additional property and application data on LUCITE® acrylic resin, TEFLON® tetrafluoroethylene resins and ZYTEL® nylon resin, mail coupon.

E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Dept.
Room 14822, Du Pont Building, Wilmington 98, Delaware

Please send me more information on the Du Pont engineering materials checked: ☐ *ZYTEL;* ☐ *TEFLON;* ☐ *LUCITE. I am interested in evaluating these materials for:*

_____

*Name*_____

*Company*_____ *Position*_____

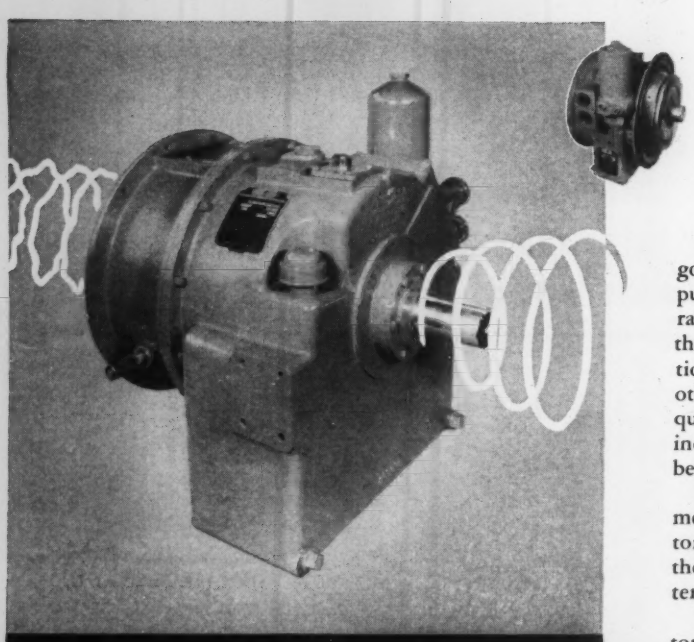
*Street*_____

*City*_____ *State*_____

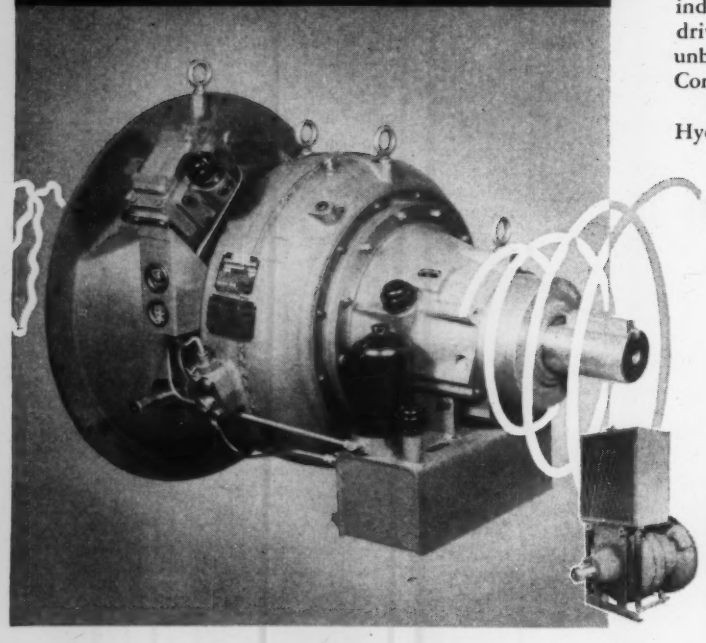
*Type of Business*_____

IN CANADA: Du Pont Company of Canada (1956) Limited, P. O. Box 660, Montreal, Quebec.

Circle 464 on page 19



Single-Stage Torque Converters or Three-Stage Torque Converters?



The answer to the question of "single-stage vs. three-stage" depends largely on the characteristics of the equipment you manufacture or use and the jobs it is required to do. Naturally, many factors must be known before any engineering department can be expected to make recommendations.

Generally speaking, however, when it is desired to have minimum pulldown from governed engine speed—with maximum power output over a wide range—and to produce high torque ratios for hoisting or heavily loaded vehicles, a three-stage torque converter, with torque multiplication up to six times, may be most desirable. On the other hand, where mild torque conversion is required, as in certain types of vehicles and in other industrial equipment—a single-stage converter may be the best choice.

Now you can benefit from the unbiased recommendations of one manufacturer in choosing a torque converter—single-stage or three-stage—with the exact capacity and torque transmission characteristics to give your equipment maximum efficiency.

Twin Disc Clutch Company's line of single-stage torque converters—available as the 1300 and 1500 Series units—complements its time-tested, universally accepted line of five series of three-stage units. Single-stage *or* three-stage—from 30 to 1000 hp—you can depend on Twin Disc Torque Converters to give your equipment better performance . . . less downtime . . . and greater earning potential.

In addition to offering the most complete, the most versatile line of industrial torque converters available, Twin Disc manufactures fluid couplings in a wide range of sizes for engines and motors from ¾ to 850 hp, and friction clutches for applications from fractional to 1050 hp.

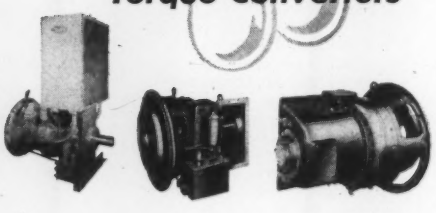
For smooth, dependable transmission of power to your equipment and machinery, standardize on Twin Disc—the world's leading manufacturer of industrial fluid and friction drives. Whatever your drive problem, you can count on Twin Disc for unbiased recommendations . . . for Twin Disc Clutch Company makes them all.

Twin Disc Clutch Company, Racine, Wisconsin; Hydraulic Division, Rockford, Illinois.

TWIN DISC MAKES THEM ALL

TWIN DISC
CLUTCHES AND HYDRAULIC DRIVES

TWIN DISC
Torque Converters



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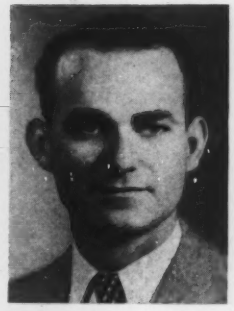
MACHINE DESIGN
August 22, 1957



Improving the Odds

MUCH has been written about the qualities engineers must possess or develop to advance, both in their company and their profession. The usual list includes technical competence, enthusiasm or "drive," ability to work with people, responsibility-assuming capacity, and personal integrity. Most engineers try to develop these faculties to the fullest.

But there are at least two special skills, which engineers can acquire, that they often overlook or avoid.

Did you ever notice that most of the outstanding authorities in any profession, including engineering, do a lot of writing or speaking, or both? It often seems the better a man can write and speak, the better his odds are for growth in his profession.

"That may be true," says Joe Q. Engineer, "but I can't waste my time or company time writing and giving speeches. I've got a job to do."

But Joe could be missing an important point.

In the final analysis, isn't Joe's job helping to develop and improve his company's competitive position? Evidence of engineering leadership and prestige is no small part of the overall picture. And some of the best salesmen of a company's engineering prowess can be the engineers themselves. A big part of such a "sales" program calls for many written and oral presentations on technical subjects by the engineers. In short, Joe can often improve company prestige by improving his own through the printed and spoken word.

"But," Joe quickly points out, "I can't write well, and I'm a poor speaker."

Joe wasn't proficient in a number of things at first. To become a good engineer requires study and practice. Good writing and speaking take practice, too.

"But where do I get the practice?" Joe asks.

He could try his hand at writing a technical-society paper or a technical article. The society paper would give Joe the speaking opportunity. Both activities will build his skill in writing techniques and organization. It isn't easy at first, but the payoff can be big. Joe may even raise his growth potential—positionwise, prestigewise, incomewise!

Robert C. Rodgers

ASSOCIATE EDITOR

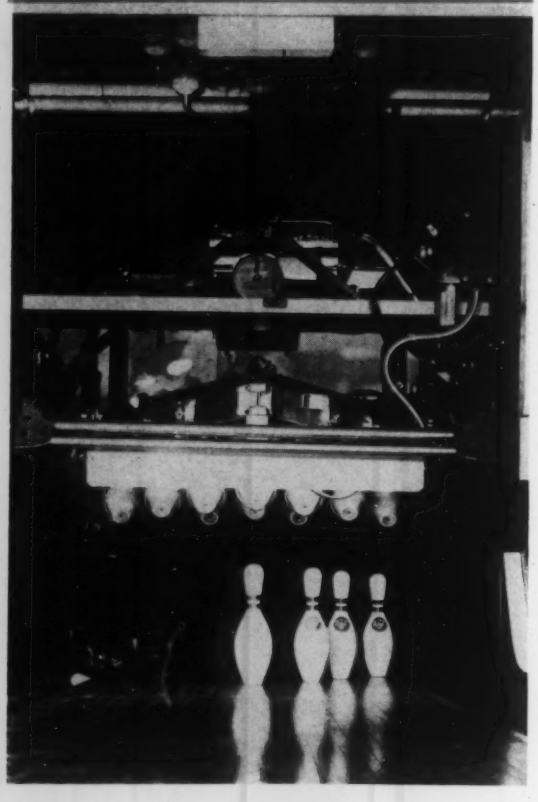
Using ideas from

OUTSIDE INVENTORS

to stimulate company product programs

By GEORGE S. HASTINGS
Vice President
American Machine & Foundry Co., New York

AMF Automatic Pinspotter represents a highly successful product venture into the bowling equipment field. First working model was built by the inventor, Fred Schmidt, at his home in New Jersey. Since buying the model and patent rights in 1939, AMF has completely redesigned the machine twice. Now, there are more than 20,000 units in operation.



MANUFACTURING companies often receive unsolicited letters describing some improvement or new idea for the company's products. Frequently, the letter will express the wish that the disclosure be held in confidence. Sometimes there is a request for compensation.

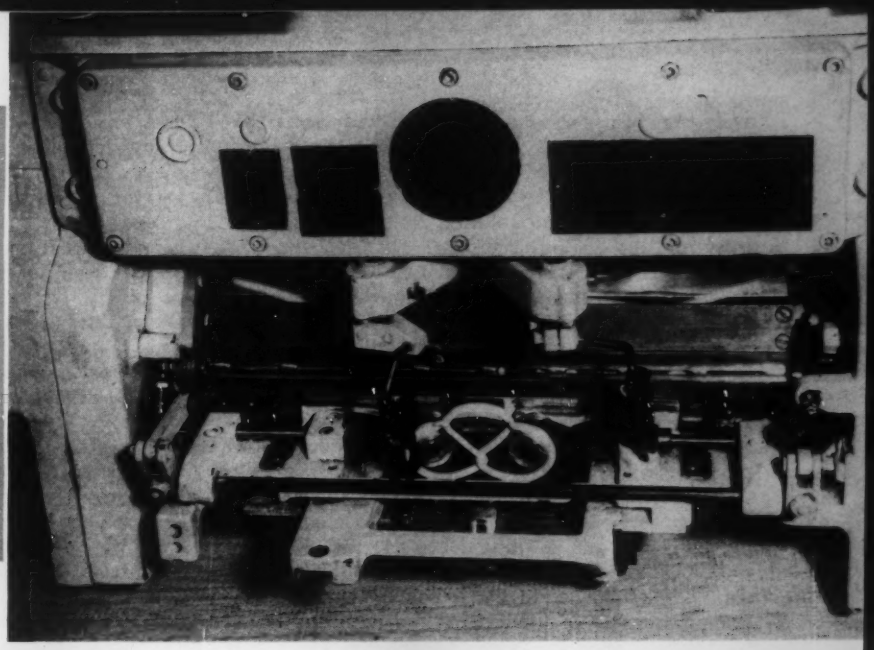
Once such a letter has been received, the company is faced with a problem which can be troublesome if it ever happens to use the unsolicited idea. Moreover, when the number of unsolicited ideas runs into the hundreds there is a chance that whatever the company may do in the way of improving its product will come close to one of these disclosures.

In the discussion to follow, attention will be given first to the problems of dealing with outside inventors. Possible solutions will then be explored with emphasis on methods of approach that can be used effectively by companies of all sizes.

The following review of a court action[1] clearly illustrates the pitfalls of such situations. Here, an independent inventor had submitted to a number of automobile manufacturers an improvement in automatic tops for convertibles. In this invention, a rubber pad operated by a folding pillar closed the top at the rear side portion as a result of the automatic operation of the top.

The inventor had filed a patent application on this device. While the application was pending, he approached one of the large manufacturers and disclosed his invention with a view to selling or licensing its use. An official of the company expressed interest and asked the inventor to leave a copy of the application for patent. Shortly thereafter the inventor was advised by the company that the idea was not feasible. Some time

[1]References are tabulated at end of article.



Pretzel-tying machine was originally conceived by a small pretzel concern, the Curthalt Co., in Canton, O. AMF acquired rights to the multiple-cam machine in 1943. Subsequent simplification of the mechanisms through several redesigns has led to the efficient model shown.

later the manufacturer put out cars with a somewhat different form of device than that disclosed by the inventor but embodying the same principle of cushion closure operated by a folding pillar.

After the inventor's patent was issued, he sued the manufacturer for damages for infringement and for violation of confidential disclosure. The Circuit Court of Appeals, reversing the District Court, held the patent infringed. In addition, the court held that the manufacturer should pay damages for breach of confidential disclosure and for use of the invention for the period after disclosure and before issuance of the patent.

But the most significant feature of this case is that this decision was made in favor of the inventor under the following circumstances:

1. The automobile manufacturer introduced oral testimony of its employees that it had the invention before disclosure. The court held that the burden of proof of earlier invention was heavily on the manufacturer and oral testimony of interested witnesses was insufficient.
2. There was at no time any express request by the inventor, or any express agreement by the manufacturer, to hold the disclosure in confidence. The same invention also had been submitted to other automobile companies prior to the defendant. However, confidential agreement was implied from the circumstances of disclosure plus the inventor's evident desire for compensation.
3. A patent application had been filed fully disclosing the invention, and what the manufacturer looked at was a copy of the patent application.
4. There was clearly novelty present in the invention.
5. The original disclosure to the manufacturer was unsolicited but later the manufacturer asked the inventor to leave a copy of his patent application. The court referred to this as "inviting" a disclosure.

The Problem

From the foregoing circumstances, it is clear that a company receiving outside ideas is faced by a ticklish problem. For its own protection, it must do something positive at the outset to negate the implication that it received the disclosure in confidence and, therefore, should compensate the submitter, if it later makes use of the disclosure. For this reason, quite a number of corporations, if they can do so, refuse to receive disclosures from unknowns. They argue that they never get ideas worth the risk and that the poor public relations from refusing to receive outside ideas is less than would result from turning down 99 per cent of the ideas received.

Even refusal to deal with outsiders does not completely solve the problem of the unsolicited letter setting forth in detail an invention for which the inventor desires compensation. It has been remarked that the only way a company could protect itself was by not reading its mail. But experience has shown that this does not always work because sometimes the inventor will show or describe his invention to sales or service personnel, or corporate executives.

It is true that much of the risk can be avoided by simply refusing to receive outside submissions and by immediately returning them with a letter explaining that it is against the company's policy to receive them. For complete effectiveness, how-

ever, the return should be coupled with some systematic procedure by which the disclosures are segregated from any of the company's technical personnel.

But is that a good solution for either the company or the inventor or, for that matter, the country as a whole? A great deal, of course, will depend on the nature of the business of the company. For example, if the company makes piezoelectric crystals for stabilizing radio frequency, it is very unlikely that it is going to get anything from the public. It might just as well follow the procedure just described, especially if it plans to base its corporate existence on the demand for piezoelectric crystals.

However, if a concern is making bicycles or bowling equipment with which millions of people are familiar, and it does not work out a way of receiving ideas from the public, it is going to cut itself off from a valuable source of corporate stimulation. It is also going to miss something worthwhile once in every 200 to 500 ideas submitted. A corporation which wishes to grow, which wants to insulate itself from the ups and downs resulting from being dependent on a few narrow lines of business, and which wants the higher margin of profit which comes from putting out something new, will want these one in 500 inventions, if it can do so with moderate risk.

An important point to be kept in mind is that it is quite possible to have large and well-staffed engineering and research departments and still miss some pretty obvious and valuable product ideas. It is not too much of an exaggeration to state that the last company to develop a telephone would be the telegraph company and the last company to devise a new kind of transportation like the airplane would be a railroad transportation company. It took Churchill and some British Navy personnel a tremendous amount of pushing to get the British Army to use a tank amidst the fearful necessity of World War I.

As a more graphic example of this point, the company that gave the public an Automatic Pinspotter was not the company that supplied eighty or ninety per cent of the bowling equipment in the country. It was instead a company whose main proprietary products were tobacco and bakery machinery. Moreover, that company got its start in this development from an outside inventor-designer in a paper-machinery factory who got disgusted with the lack of pin boys.

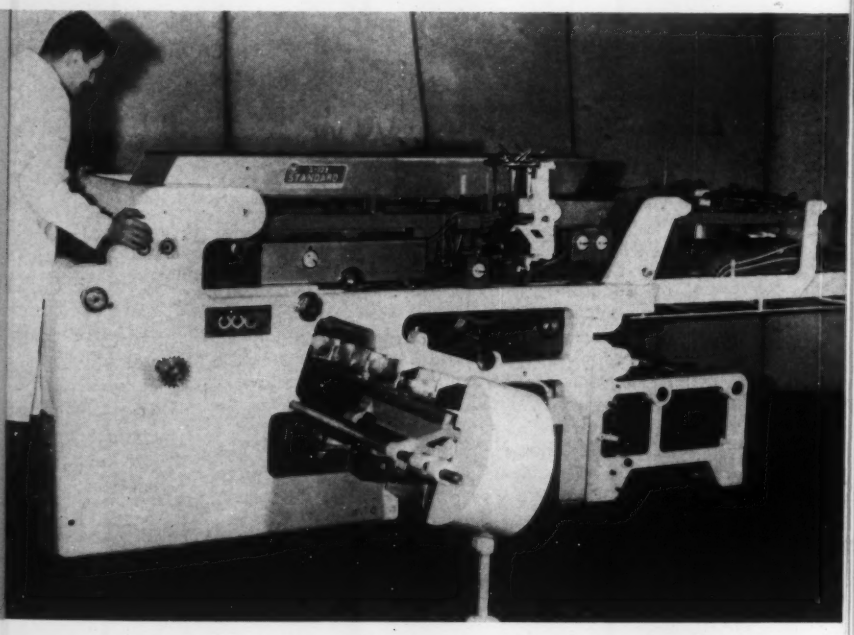
Each year from 1936 through 1956, with remarkable consistency, about 40 per cent of all U.S. patents are issued to individual inventors. This is a much higher percentage than the figure for manufacturing volume by individuals.

If the time comes when there is no place for the individual inventor because companies are unwilling to take the risks of considering their inventions, our economy as a whole, as well as individual corporations, will have lost a valuable source of stimulation. Also the U.S. patent system will have failed in a major respect and will become much more vulnerable to political attack.

Thus, it is apparent that at least a tolerable solution to this problem of receiving outside ideas would be desirable. Analyzing the somewhat conflicting law on this subject may be helpful.

Basic Concepts

Under the common law the creator of an idea owns that idea. He can practice it in secret and will be protected in maintaining that secrecy. When

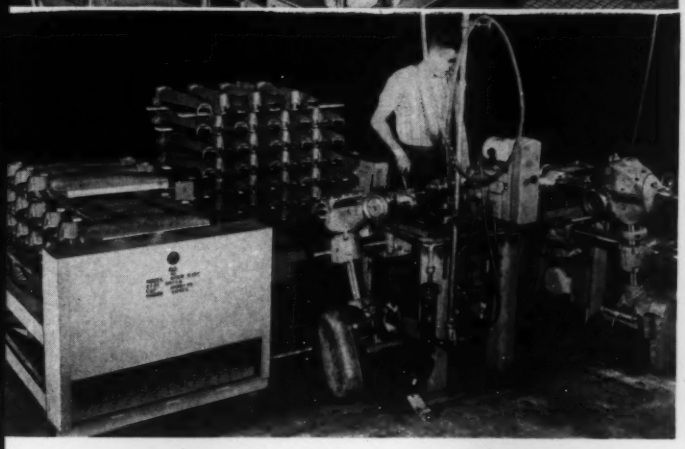


Bread wrapper is one of AMF's oldest products. It started with the discovery of a new principle for feeding a roll of paper and wrapping it around a loaf of bread. In 1925, a small working model and rights to patents were acquired from the inventor, Harry Armstrong. Since then, several models have been designed and perfected, the one shown being the latest version.

and if he discloses his idea, however, the creator's rights depend upon the method of disclosure and the precautions taken in disclosing it. If he copyrights it, he retains the protection resulting from such registration. If he patents it, he retains the protection allowed by his claims for seventeen years. The broad rule is that there is no residual property interest protectible by law in an idea or disclosure which is communicated to third parties *without reservation*. To hold the recipient of his disclosure, the inventor must show (1) something more than the mere disclosure of his mental labors and (2) use for profit by the one to whom disclosure is made.

As Justice Brandeis stated[2] in a Supreme Court decision: ". . . to appropriate and use for profit, knowledge and ideas produced by other men, without making compensation or even acknowledgment, may be inconsistent with the finer sense of propriety; but with the exceptions (under copyright and patents statutes) or in cases of special relationship 'where the suit is based upon breach of contract or of trust or upon unfair competition' the law has heretofore sanctioned the practice."

Lowerator self-leveling dispensers joined the AMF product line in 1945 when the company acquired the partnership of the two inventors, William Gibbs and Ernest Smith. The table-on-a-spring idea has been adapted for many uses, both in restaurants and in industry as parts-handling equipment.



The general rule is not very helpful. The problem lies in the exceptions and the cases of special relationship, depending on the circumstances under which the disclosure was made. There are several grounds for recovery.

IMPLIED CONTRACT: This condition is the main source of difficulty. It generally includes two elements: (1) an implied agreement to keep confidential if no arrangement is made with the inventor and (2) an agreement to compensate if the idea is used. The second stipulation is generally implied from the agreement to keep confidential on the basis that the company should not be allowed to profit from its breach of confidence. The troublesome thing is that often there is no request for confidential treatment and no thought on the part of the company that it is agreeing to such a request. But the jury implies this from the circumstances, with consequences which the company never contemplated.

UNJUST ENRICHMENT: This premise generally requires willful and knowing appropriation of the idea or invention. Also the idea or invention ordinarily has to be novel. Although not relied on as much as the implied-contract theory, the unjust-enrichment argument is often used to buttress the implied-contract basis for recovery.

EXPRESS CONTRACT: This situation arises when the inventor asks for compensation and for the disclosure to be held confidential, and the company expressly assents. It is not of immediate concern. However, assuming the idea is unpatentable, it is easy for a company expressly to agree to hold confidential and, if the idea has been published, find itself the only one in the world that cannot use the idea without paying for it.

PATENT OR DESIGN PROTECTION: This point is also of secondary importance. If the protection is valid and infringed, a license is negotiated. Anything not claimed is free to the public.

From this brief review of the different courses of legal action possible, it is apparent that several factors can influence the degree of risk to any company accepting outside ideas. However, based on previous court decisions, there are certain "tests" that can be used as a guide in determining the kinds of ideas or inventions which when disclosed to a company will not subject it to a suc-

NuMode tie - stitching machine is designed for a single operator. In 1938, AMF acquired rights to manufacture the machine under a patent held by Newman and Opper. This simple design has since been greatly improved both functionally and appearancewise.

cessful suit for compensation.

1. The disclosure must be concrete and specific and not expressed in general undeveloped form. Vagueness and indefiniteness are ordinarily fatal in the absence of an express contract.

2. The chances of success in a court action are greatly decreased by lack of novelty in the disclosure. Certain cases, particularly in Illinois, state that novelty is not necessary where the idea is new to the party receiving it, or the circumstances are sufficient to show an implied or express agreement to keep the disclosure confidential and, thus, not to use it without compensation.[3,4] However, the weight of decisions in other circuits is to require novelty in the absence of an express contract to hold confidential and to compensate. But such novelty does not have to be patentable novelty. Thus, it is quite possible for the claims of the patent to be held invalid, with the inventor recovering on the basis of use for profit of the submitted ideas disclosed in confidence, as occurred in a District Court action in Indiana.[5] In this case it was held that there should be recovery for that which was novel though not patentable, but no recovery for using those ideas disclosed in confidence which were not novel.

3. If the idea becomes public, as by public use or publication, through the act of the inventor prior to use by the company, the company has been held not liable thereafter even though it received the idea in confidence before public use.[6]

4. If the company already has its own independently developed idea and uses that, it is not obligated to compensate an outside inventor even though the inventor gave the same idea in concrete form to the company prior to its use of the idea.[7] However, the burden of proof that the company had the idea first is heavily on the company.

It has also been held that if, before a disclosure is made, a corporation is careful to require the inventor to sign a document which provides in effect that the corporation is under no obligation to him respecting any use or disclosure, the corporation is protected.[8] The catch, however, is that quite often the corporation does not have a chance to get a signature. But this procedure is very worthwhile wherever there is an opportunity, as when the inventor states, "I have an idea," and the corporation jumps in and says: "Stop right there. Here's our waiver Form 356."

There is also authority for a similar procedure in the situation where the disclosure is received with sufficient concreteness, as through the mail, without opportunity to get a signature to a waiver agreement. If the corporation gives or forwards a statement of the conditions under which it can or will receive disclosures and states that it does not accept any disclosures on a confidential basis, or with any agreement to compensate, but requires that the inventor rely on his rights under the patent laws, then there is a serious impairment to the creation of a confidential relationship in such case. In a decision[9] under such circumstances, the court rejected an attempt to imply an agreement to hold confidential. Furthermore, it stated that the essentials of breach of faith and use of confidential disclosure consist of knowledge, and an understanding, express or implied, that there was to be compensation and that the invention was to be kept secret. It also required, as essential, that the invention or disclosure be novel, differing in this respect from the Illinois courts.

The Solution

A number of companies have considered this problem carefully and have decided that it is worth the risk to receive outside ideas. They have set up a procedure somewhat as follows:

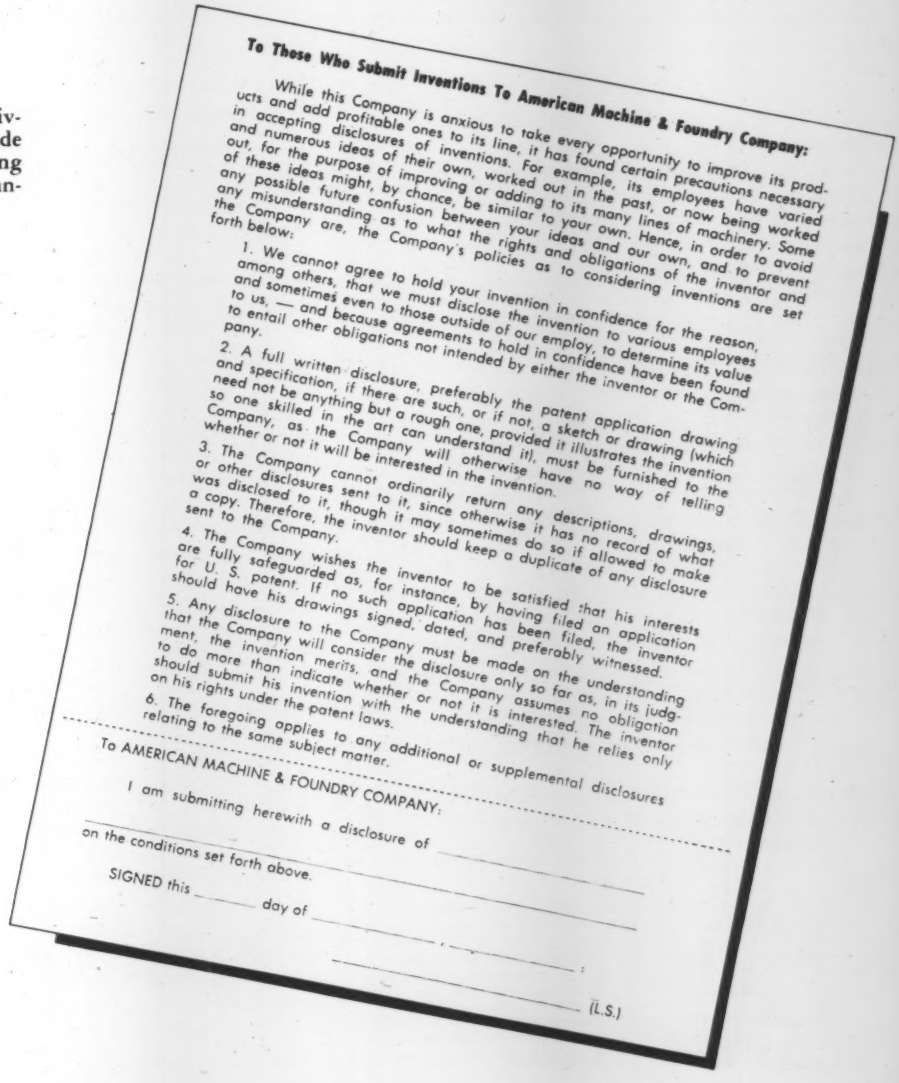
1. Personnel likely to receive such disclosures

are instructed to send them immediately to one administrative person, often in the company patent department, who has the responsibility for handling such disclosures. Any letters that are recognized in the mail as being such disclosures are immediately forwarded to this administrative person. So far as possible, such disclosures are systematically kept segregated from technical or engineering personnel until the "ground rules" have been settled with the outside inventor.

2. A waiver form instruction booklet is sent to the inventor and he is asked to sign a sheet and return it. This sheet sets forth the basis on which the company will receive such disclosures. One company's form has ten conditions. The first negates a confidential relationship. Second, no commitment is made that the idea or material will be kept secret. Third, the company does not agree to pay any compensation but it gets no rights under any claims of a patent which may issue to the inventor. Fourth, it is suggested that the inventor's sole remedy is to enforce his rights under the patent. As a matter of good public relations, the reasons for these conditions of submission are then set forth.

American Machine & Foundry Co. uses a slightly different form, Fig. 1. In comparison, the company previously mentioned includes another feature. If it does use the idea submitted and the idea is unpatented, the top price that can be demanded and that will be paid by the company is $1000.

Certain practical precautions should be observed in dealing with outside inventors. Avoid having the discloser sit down and talk with company engineers working in the same field. This will happen unless advance precautions are taken. Have him talk first with some administrative nontechnical person who will give him the waiver sheet, and ask him to communicate his ideas in writing



To Those Who Submit Inventions To American Machine & Foundry Company:

While this Company is anxious to take every opportunity to improve its products and add profitable ones to its line, it has found certain precautions necessary in accepting disclosures of inventions. For example, its employees have varied and numerous ideas of their own, worked out in the past, or now being worked out, for the purpose of improving or adding to its many lines of machinery. Some of these ideas might, by chance, be similar to your own. Hence, in order to avoid any possible future confusion between your ideas and our own, and to prevent any misunderstanding as to what the rights and obligations of the inventor and the Company are, the Company's policies as to considering inventions are set forth below:

1. We cannot agree to hold your invention in confidence for the reason, among others, that we must disclose the invention to various employees and sometimes even to those outside of our employ, to determine its value to us, — and because agreements to hold in confidence have been found to entail other obligations not intended by either the inventor or the Company.

2. A full written disclosure, preferably the patent application drawing and specification, if there are such, or if not, a sketch or drawing (which need not be anything but a rough one, provided it illustrates the invention so one skilled in the art can understand it), must be furnished to the Company, as the Company will otherwise have no way of telling whether or not it will be interested in the invention.

3. The Company cannot ordinarily return any descriptions, drawings, or other disclosures sent to it, since otherwise it has no record of what was disclosed to it, though it may sometimes do so if allowed to make a copy. Therefore, the inventor should keep a duplicate of any disclosure sent to the Company.

4. The Company wishes the inventor to be satisfied that his interests are fully safeguarded as, for instance, by having filed an application for U. S. patent. If no such application has been filed, the inventor should have his drawings signed, dated, and preferably witnessed.

5. Any disclosure to the Company must be made on the understanding that the Company will consider the disclosure only so far as, in its judgment, the invention merits, and the Company assumes no obligation to do more than indicate whether or not it is interested. The inventor should submit his invention with the understanding that he relies only on his rights under the patent laws.

6. The foregoing applies to any additional or supplemental disclosures relating to the same subject matter.

To AMERICAN MACHINE & FOUNDRY COMPANY:

I am submitting herewith a disclosure of _____

on the conditions set forth above.

SIGNED this _____ day of _____, _____

_____ (L.S.)

Fig. 1—Typical waiver form for outside inventors submitting product ideas to manufacturing firms.

to the central patent person designated to receive it.

Since 200 to 500 of these submissions will be received for every acceptable and usable idea, a form letter will have to be worked out for rejection of impractical inventions. When submissions describing a concrete invention or ideas are rejected, retain copies of the disclosure so there can be no dispute as to what was disclosed. Because a public relations problem is involved, the rejection letter should be designed accordingly.

Wherever possible, get the waiver sheet to the inventor *before* he submits his idea in detail. Quite often the inventor will write in asking about the possibilities of an idea for accomplishing such and such result. Such disclosures are a pleasure to deal with. If he is asked to state simply what result or advantage he expects to get from his disclosure and what field of industry it relates to, the decision can quite often be made as to whether the corporation is interested without ever receiving a concrete disclosure. In any event, the company can get its waiver sheet in first.

One proposed solution is to have a completely independent consulting firm receive, process and screen disclosures, carry on any correspondence, and turn over the good ideas to the client corporation. There is a consulting firm which offers to do this but, of course, at a charge for the service.

Sometimes a corporation has submitted to it in considerable detail an idea on which it is already working and planning at some future date to use. The question then arises as to whether, in turning down the submitted material, the company should disclose the fact that it already has the same material developed. Perhaps as good a way as any of handling such situations is to include in the waiver sheet a paragraph stating that the company is under no obligation to reveal any information regarding its activities in the field to which the submitted idea pertains, even though the company has a similar idea under development.

The fact that the inventor is a company employee under employment contract does not necessarily mean that the company is free from the problem of the outside inventor. If the invention is one which was made before the employment contract came into effect, or is one of the class of in-

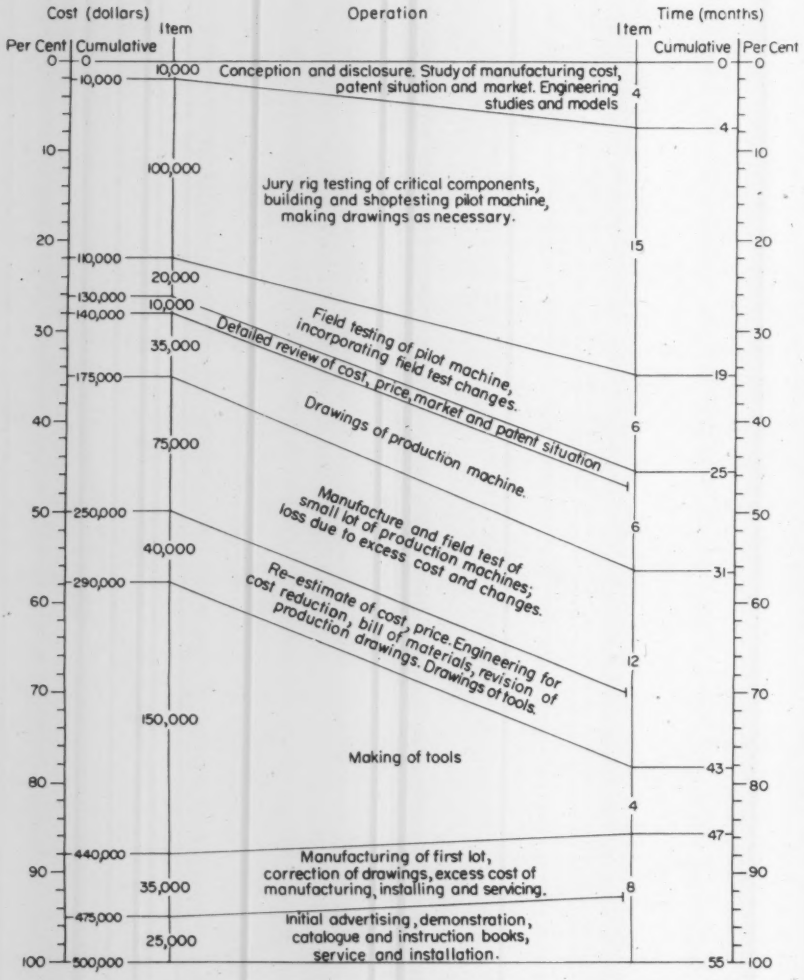


Fig. 2 — Typical cost and time requirements to carry an invention from conception to commercial production. Values are based on the development of a pioneer machine of medium complication (such as a high-speed bread-wrapping machine), selling for $10,000, and to be manufactured in lots of 50 for a total market of 2000 machines.

ventions which was excepted from operation of the contract, the employment relationship has no bearing.[9]

Should a company solicit ideas from outside inventors?

Corporate concensus on this question is emphatically **no!** This article is definitely not to be interpreted as a solicitation. One reason for this viewpoint is that solicitation increases the legal risk. Another reason is that any sort of solicitation tends greatly to increase the number of ideas to be screened without a corresponding increase in the number of useful ideas received.

After all formalities have been taken care of and the outside idea has been safely received, how does a company evaluate these outside inventions? Some companies have a special commercial research department for making such studies, both with respect to outside inventions and to those of its own employees relating to new or improved products. There are several steps common to good evaluation procedure. Such steps are:

1. Determine technical feasibility of the idea. This involves engineering study. Can it be made to work without undue complication or cost?

2. Determine patent feasibility. Can the invention and subsequent development work be protected? Is the invention free from infringement?

3. Get as much data with respect to the market and to customer reactions as possible.

4. Study the relationship of the invention to the company's business. A good way of doing this is to line up on one side a list of the company's manufacturing and other facilities, skills, selling ability, research and engineering background, and so on. On the other side, list the requirements of the submitted invention. If such a line-up indicates that the company cannot make much of a contribution toward developing, manufacturing and marketing the product as compared with many other companies in the field, then the profit possibilities would have to be very attractive to tempt the company to take on development of the product.

5. Consider degree of product completion, Fig. 2. The value of a submission depends very greatly on how far along the scale from conception to commercialization the product is located. The risks and costs increase greatly in accordance with how close to conception the idea is; they are least at the other end of the scale when a going business is being considered.

6. Determine product worth. It is possible to draw up a formula for this determination; that is, $X = PS/C$ where P = cumulative net profits over the probab'e commercial life of the product, S = chances of success and C = cost of carrying the project through from beginning to successful commercialization, including any payments to the inventor.

Quantity S is expressed as a fraction of 1, which would represent complete success. This value is determined by multiplying a series of fractions. For instance, if it is estimated that there is one chance in ten that the engineering problems cannot be solved at a reasonable cost the fraction inserted is 9/10. This evaluation is established for every known risk.

In general, if X does not equal approximately 3 for a product close to the company's business or 5 or more in something rather remote from the company's business, then the project is probably not worth considering.

How is a fair royalty determined for the outside inventor? Referring to the six foregoing items, it can be seen that the more favorab'e these items are, the larger the royalty justified. Unfortunately, the average inventor tends to work the other way around. The earlier the stage of development of the invention, the more optimistic he is. Here is where the negotiator for the corporation has to be rather hardheaded. He must look at it from the point of view of profits to the company. Today, it is a good manufacturing business which in the long run yields more than 15 per cent pretax (about 7 per cent after taxes) on the sales dollar. He will be giving one third of the pretax net profits if he gives the inventor 5 per cent. Thus, this amount probably should be about the top royalty for a potentially quite profitab'e invention near to the marketable stage, and the royalty should taper way down for inventions which have not been developed to any degree.

If a company manufactures products about which the public is somewhat knowledgeable, it seems a mistake for it to cut itself off from the public's ideas relating to these products. It is not only poor public relations but sooner or later the company is going to miss an idea or invention that is worth all the risk and much more. The fact is that even the best of corporations may become a little ingrown on their proprietary lines of products, and anything that shakes up their routine thinking is valuable and well worth what it may cost in a compensation for outside inventions. According to the experience of a number of corporate patent departments, not one of their companies has lost more on outside inventions than the cost of operation of their research departments for a month or two.

In the author's opinion, it is not only good public relations to receive outside ideas, with what precautions are possible, but it is good business.

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4. Spellman Products v. Qualley Allen Co., 36 *Fed. 2nd* 623.
5. Booth v. Stutz Motor Car Co., 13 *USPQ* 12.
6. Northrup v. Reish, 96 *USPQ* 78.
7. Franke et al v. Wilschek, 292 *Fed. 2nd* 493.
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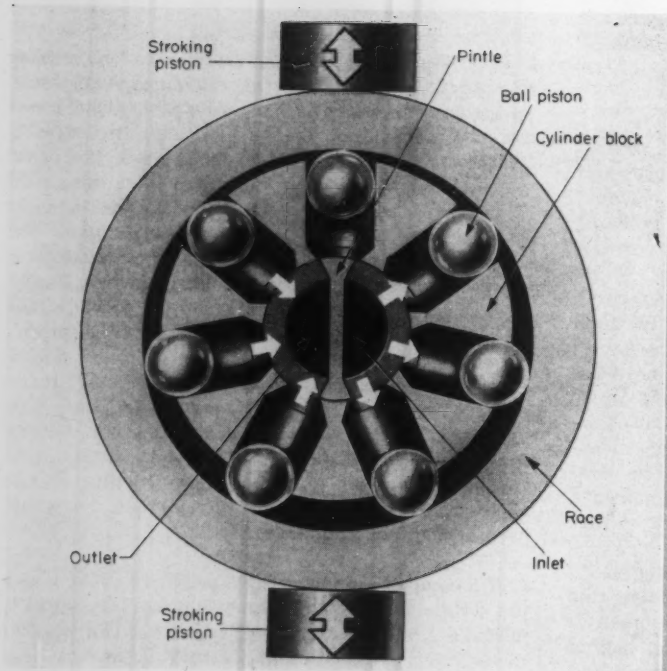
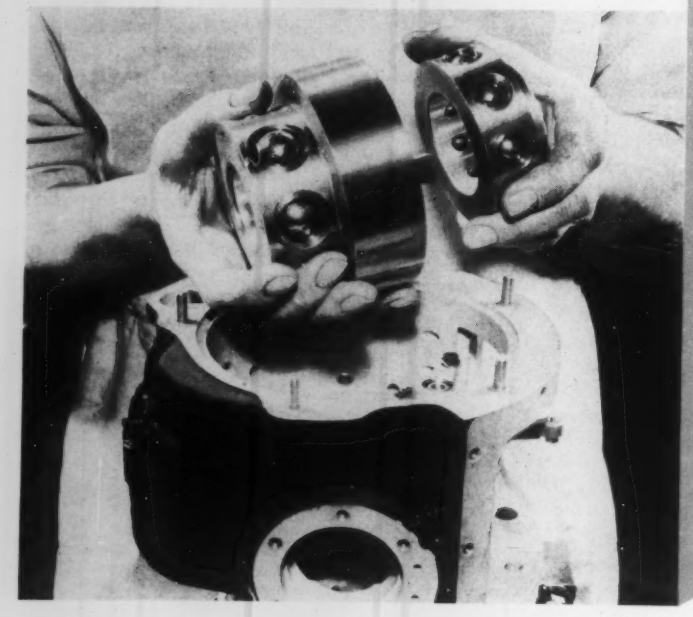
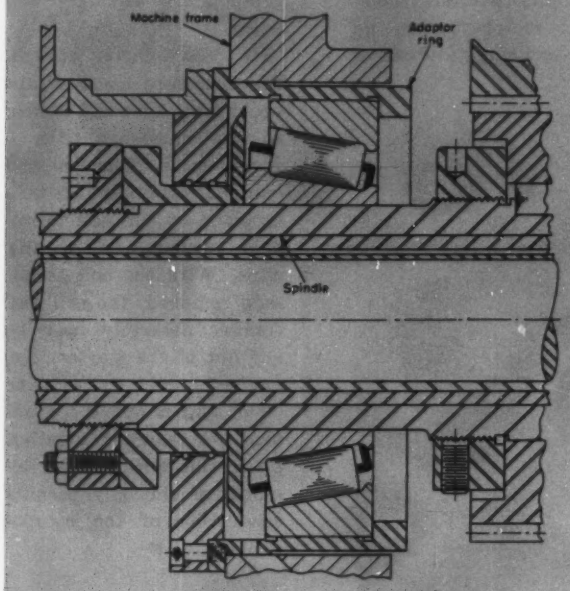
scanning the field for *ideas*





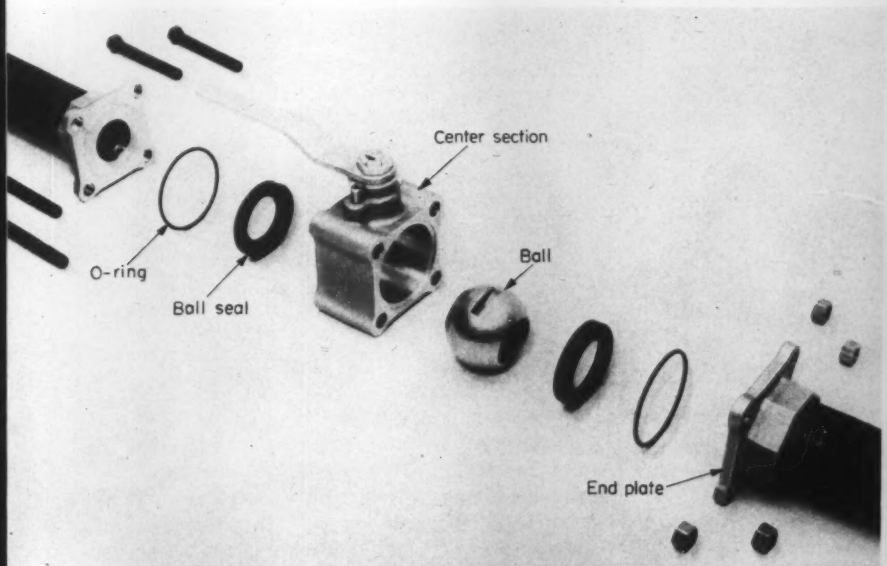
Ball pistons simplify design and reduce friction losses of a radial-piston hydraulic pump-motor. Developed by General Electric, the design is employed to reduce size and weight of pump-motors used in constant-speed drives.

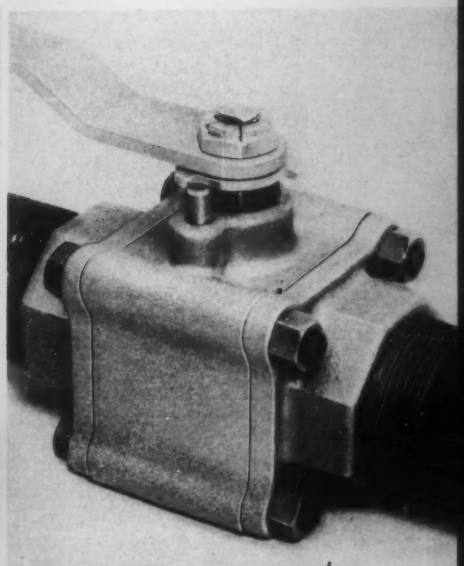
In this design, the ball pistons are located in precision holes in a rotating cylinder block. Centrifugal force from high-speed rotation of the cylinder block maintains the balls in rolling contact with the race. The inlet and outlet ports are in the nonrotating pintle for the cylinder block. Displacement adjustment for the unit is provided by lateral shifting of the race in relation to the center of the cylinder block.



Semiflexible bearing mounting accommodates dimensional changes in bearing over a wide speed range. Designed by Cleveland Automatic Machine Co. for the rear spindle bearing of an automatic screw machine, an adaptor-ring mounting permits operation from 130 to over 2000 rpm without adverse effects due to bearing expansion or contraction.

The adaptor ring fits tightly into the machine frame at one side, but floats freely at the opposite side. Under temperature conditions of high-speed rotation, expansion of the adaptor accommodates axial expansion of the bearing outer race. Radial expansion is permitted by the resilience of the adaptor ring and its lack of confinement.



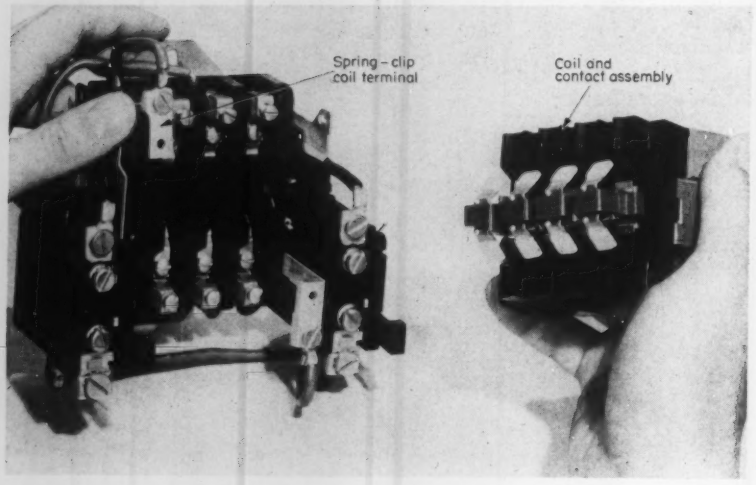


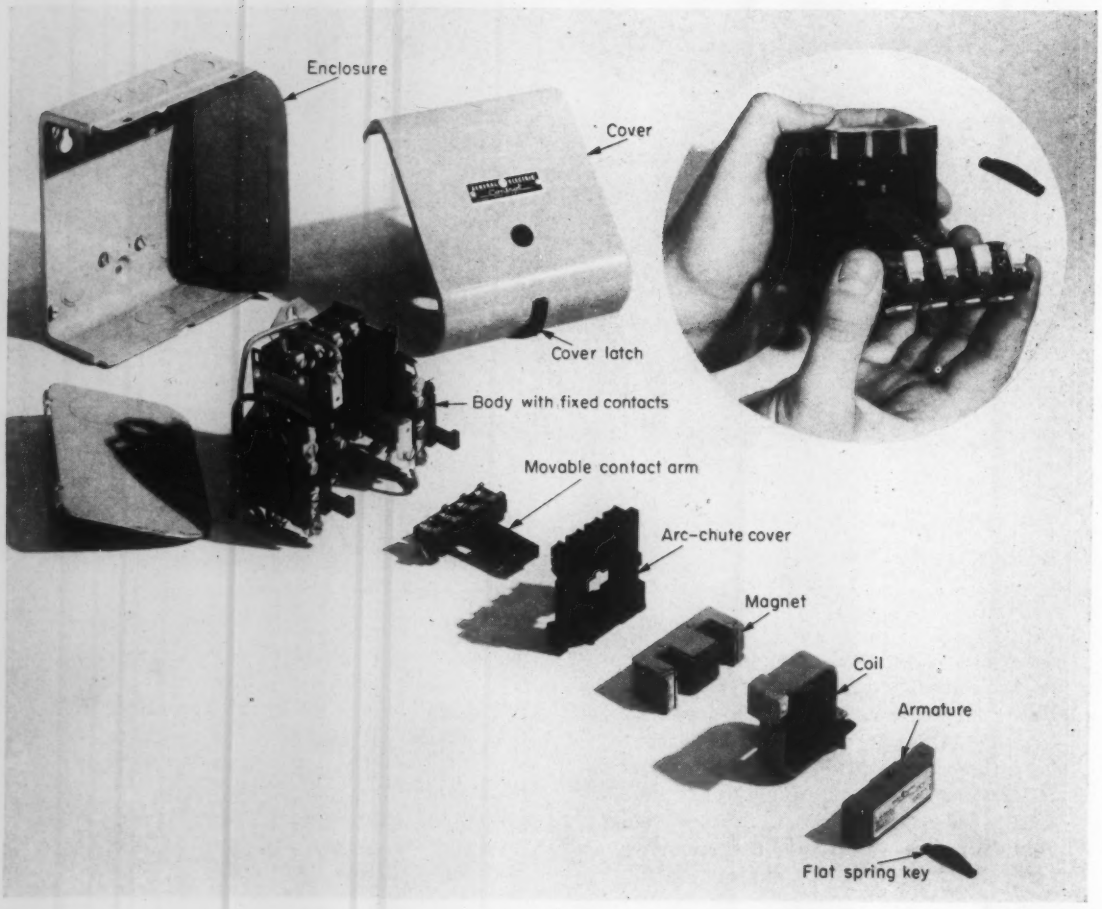
Sectioned valve body simplifies "plumbing" problems and facilitates removal and replacement of valve parts. In a design developed by Worcester Valve Co. Inc., the body is in three pieces: two end plates and a center section.

The end plates function as pipe flanges, eliminating separate flange fittings or unions in the line. All of the valve mechanism and the seals are contained in the center section. Bolts join the end plates and the center section into an integral unit, with leakage prevented by removable O-ring seals. Inspection, maintenance and seal replacement can be performed by simply removing the bolts and lifting out the center section.

Snap-slide construction of electrical apparatus permits quick disassembly and reassembly of principal components without tools. Developed by General Electric for use in an electric-motor starter, the design is based upon a mechanical interlocking technique. When a "key" is removed, the components virtually fall apart.

In this starter design, the enclosure cover wraps around the unit and is held to the enclosure with a spring latch. The coil and contact assembly is held in place by the coil terminals, which are spring clips. With the coil terminals removed, the coil and contact assembly may be slid out of the starter. The magnet, coil, arc-chute cover and movable contact arm are fastened together by a flat-spring key. Removal of this key permits separation of the components.





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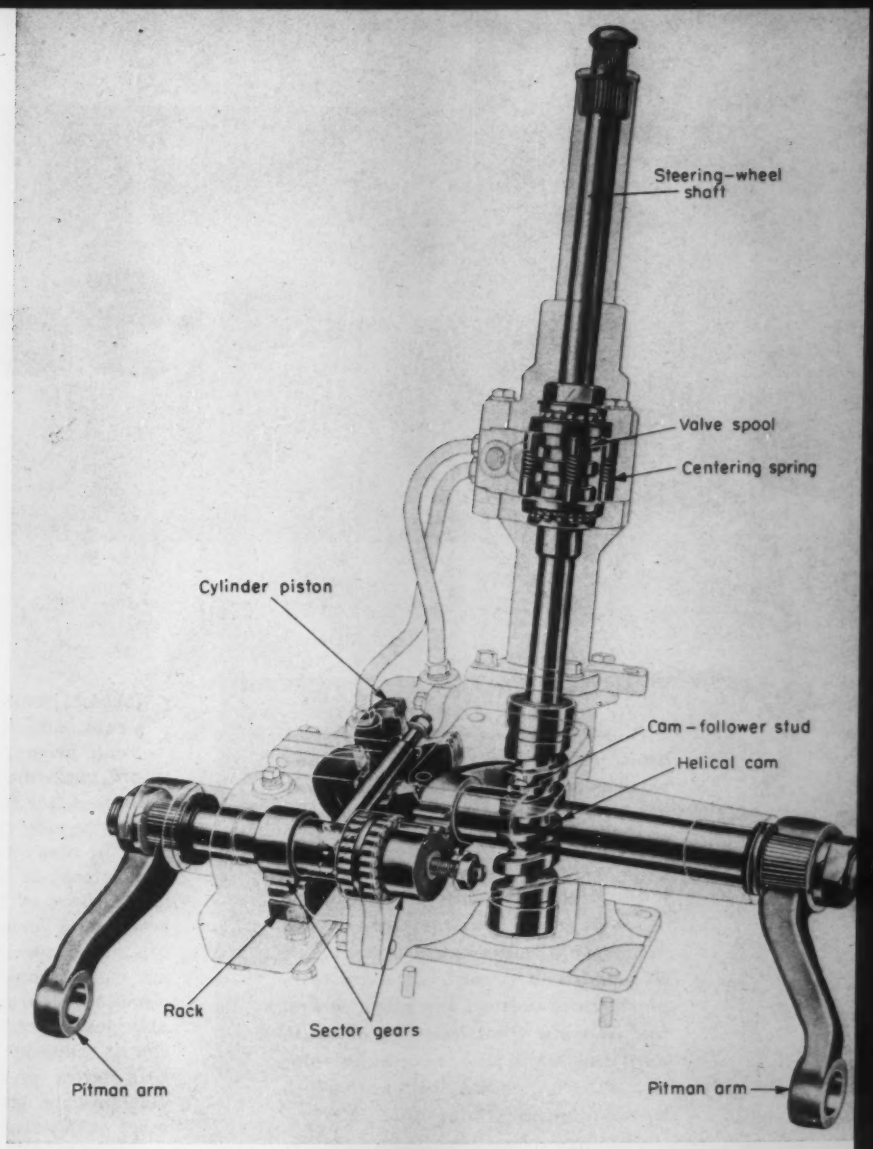
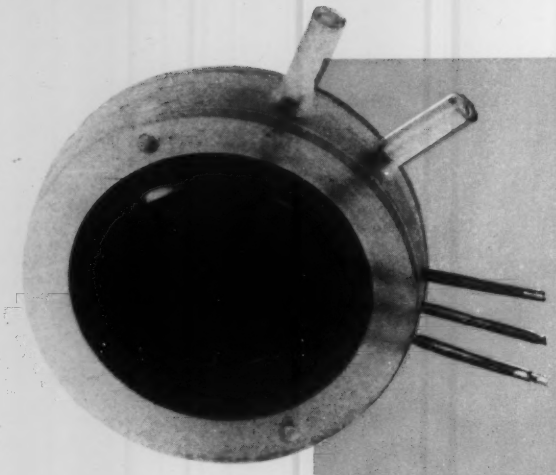


Automatic Shock-load compensation in a hydraulic-cylinder circuit is provided by an unusual "self-neutralizing" control system. Under normal operating conditions, the system allows slow "coast back" of the cylinder piston. A spring-loaded valve spool is mounted on a common shaft with a helical cam which, through a follower and gearing, is connected to the piston rod of the hydraulic cylinder. Forceful rotation of the spool shaft causes it to move axially due to the helical cam, opening the valve. While the valve spool is being rotated, fluid is admitted to the cylinder. Piston movement in the cylinder re-establishes the helical cam in its original position and closes the valve.

Developed by International Harvester for a tractor power-steering system, the design provides power assistance if resistance is encountered while the steering wheel is being turned, yet permits automatic self-return because slow movement of fluid between ends of the cylinder is permitted while the valve is in neutral. Road shocks are compensated for by being transmitted through the gearing to move the valve spool and open the valve momentarily.

A hard turn of the steering wheel causes the shaft with the valve spool and the helical cam to overcome the spool-centering springs and to move axially as the cam "threads" past the cam-follower stud. This short (⅛-in.) axial movement opens the hydraulic valve. Movement of the piston is transmitted through a rack and pinion to the pitman arms, which are joined by sector gears. One of the sector gears is also the cam-follower lever, so piston movement also re-establishes the valve on neutral by axial movement of the helical cam and the valve spool. The centering springs on the valve spool tend to keep it on neutral. This action assists re-establishment of original axial position of the helical cam and of neutral spool position, which permits enough fluid movement within the system for automatic self-return of the steering wheel if it is released. Shock loads are transmitted directly through the sector gearing to the cam follower, moving the helical cam axially and opening the valve for compensating flow to the cylinder.



Solions

A series of new electrochemical transducers was recently demonstrated to over 100 representatives of industry, research and government at the U.S. Naval Ordnance Laboratory in Silver Spring, Maryland. Highly responsive to changes in temperature, pressure, light, sound or motion, the devices are controlled and operated according to the laws of electrochemistry. Since the control and sensing characteristics of these units involve motion of ions in solution, they are called "solions," which is pronounced so'-lee-ons.

Many scientists predict that solions will probably call for the development of a whole new technology, dubbed by some as "chemtronics."

The basic theory and technology of solion units is now fairly well understood. One large area of application is in the design of hydraulic-electrical circuits complementary to those of semiconductor devices, such as transistors. In certain low-frequency and integrator applications, solions are superior devices. At present, these electrochemical units cannot be used in place of electron tubes and transistors in many circuit applications, particularly in the middle and high frequencies. The main function of solions now is to produce electrical outputs from nonelectrical stimuli.

SMALL in size, highly sensitive, extremely accurate, and low in power consumption, solions can accomplish many of the functions heretofore performed only by electron tubes and transistors. After full development, these electrochemical units may be more selective, sensitive and efficient in many applications than electron tubes or transistors. It is fully expected that electrochemical devices of this type will make possible more economical, smaller and simpler instrumentation, Fig. 1. Even now, many transistorized circuits are more complicated than electrochemical element circuits performing the same function. Considerably less electrical power is required by a solion circuit than in a comparable transistor circuit.

In terms of size and cost it is claimed that a vacuum-tube circuit would be larger, heavier and more expensive than an electrochemical circuit designed for the same function.

The main disadvantage of solions is the limited operable frequency range, presently lying between 0 and 200 cps. Also, the solion cell itself is larger than transistors and is larger in some dimensions than many miniature vacuum tubes.

Principle of Operation: Generation of electrical current occurs in the device when ions are caused to move between electrodes through an iodine solution. Current flow is excited initially by a low-voltage, dry-cell battery connected in series with the electrochemical unit as shown in Figs. 1 and 2. Solion current is then sustained and varied by outside stimulation of the unit with changes in temperature, pressure, light, sound and motion.

The solion is polarized by a special-design battery developed by scientists Herbert B. Reed and Monroe B. Goldberg, Naval Ordnance Laboratory, Fig. 1. Other types of low-voltage batteries may be used, however. The NOL battery, disclosed several weeks ago, is a silver-lead, alkaline, rechargeable dry battery with a long shelf life and possessing the ability to deliver 0.9-volt over long

. . . revolutionary electrical control elements highly sensitive to heat, pressure, light, sound or motion. The future for these new electrochemical devices is as broad as for transistors and electron tubes.

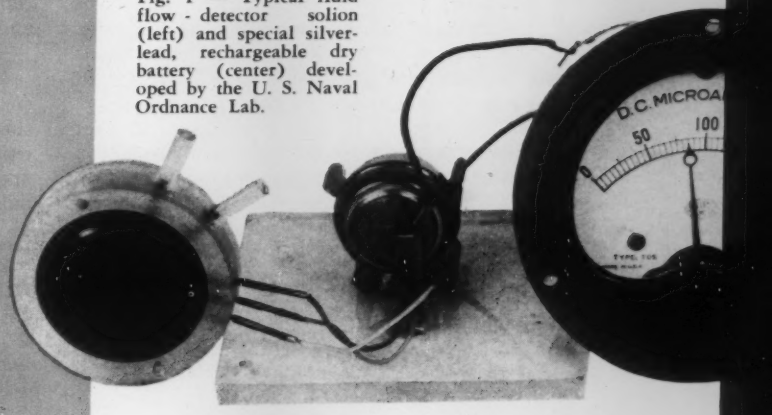


Fig. 1 — Typical fluid flow - detector solion (left) and special silver-lead, rechargeable dry battery (center) developed by the U. S. Naval Ordnance Lab.

periods. Highly shock resistant, it is estimated to have a useful life of 10 years or more.

Fluid Flow-Detector Design: By careful control of electrode design, linear or logarithmic current outputs versus fluid flow may be obtained.

A typical flow detector is shown in Fig. 2. Electrodes may be of any metal which is inert to the electrolytic system used. In this particular example, platinum electrodes are used in an electrolytic system of iodine and potassium iodide in water. Cathodic reduction of iodine is made the controlling reaction by using a low concentration of iodine and a high concentration of the supporting electrolyte, potassium iodide. Current in the system is evidently controlled by the number of negative iodine ions which come into contact with the cathode. When there is no electrolyte flow through the cathode orifice, the current is controlled by diffusion; fluid flow of the electrolyte increases the number of available negative iodine ions at the cathode, and the current in the system increases. The reactions within the detector are reversible and there is no depletion of the unit during the chemical processes. Other electrolyte systems may be used: for example, ferricyanide-ferrocyanide, bromine-bromide, ceric-cerous, ferric-ferrous, etc. It is only necessary that they be reversible redox systems, which are reversible, chemical oxidation-reduction systems. A plot of the equilibrium current as a function of the incident pressure is shown in Fig. 3.

Fig. 4 shows the type of response which may be obtained from a detector system with an electrode geometry which yields a logarithmic current output with respect to acceleration of the electrolyte. A range of three decades in acceleration was achieved by a simple instrument consisting of an electrochemical detector, a battery, and a microammeter. No switches or other controls were used to cover the three log steps of acceleration from 1 cm/sec^2 to 10,000 cm/sec.^{2}

The cell in Fig. 2 was designed primarily for detecting and metering of acoustic energy or ac pressures. A more satisfactory design for dc flows and pressures is shown in Fig. 5. In this cell design, an additional cathode is placed in the right-hand compartment so that the bias voltage transfers the iodine from this side to the anode side, resuling in a final concentration of virtually zero in the cathode side.

The working or detecting cathode consists of a small piece of closely woven platinum gauze situated in an orifice between the two compartments. Flow from left to right (concentrated to

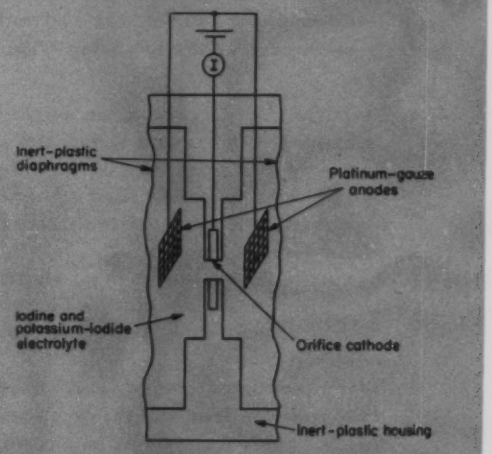


Fig. 2—Circuit of solion flow detector, polarizing battery and ammeter shown in Fig. 1. Designed primarily for detecting and metering acoustic energy or ac pressures, the solion consumes 1/100 to 1/1000 the power required to operate a transistor.

dilute solution) produces an electrical signal directly proportional to the magnitude of the flow. By suitable design of the detecting cathode, linear current outputs are obtainable over a range of four orders of magnitude in the flow rates.

The unit in Fig. 5 is also a *rectifier,* in that fluid flow from right to left will not produce a current, since no iodine is carried over the detector gauze. A full-wave detector may easily be constructed by using two anode compartments and two detector gauzes.

Electro-Osmotic Cells: To perform various mathematical operations upon the output currents of the previously described flow detectors, it is necessary to have a unit that carries out the reverse operation of converting low-power electrical signals into fluid flows. Thus, electrical and fluid-

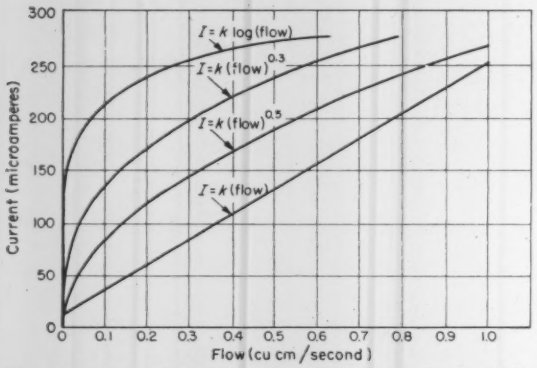


Fig. 3—Curves of electric current vs. flow of electrolyte through the cathode orifice for solion acoustic detectors, such as shown in Figs. 1 and 2, with different orifice designs. The constant *k* depends on cathode geometry.

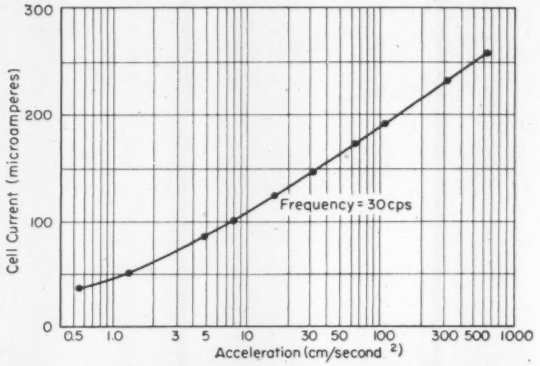


Fig. 4—Typical calibration curve of an accelerometer. Current-output is nearly logarithmic to acceleration. Motion applied along axis of cylindrical symmetry of the accelerometer cell.

Present and Future Applications

Although the Navy developed the solion for ordnance use, its wide commercial application by industry is considered by NOL scientists to be quite feasible and durable.

Lyman C. Fisher, chief of NOL's Underwater Mechanical Engineering Dept., predicted that in their present state of development electrochemical units can advantageously be applied to the following types of circuitry:

1. **So-called "rate" circuits, or derivative units, to give maximum speed and accuracy in the operation of heat controls, burglar and fire alarms, furnace regulators, and pressure indicators.**
2. **Sound-sensitive meters.**
3. **Product circuits involving electrical derivatives or hydraulic flow, or both.**
4. **Electrical and small-signal hydraulic amplifiers.**
5. **Integration units requiring continuous high precision read-out for acceleration (inertia) guidance systems in aircraft.**

Flight Integrator: Test models of an electrochemical flight integrator, already produced industrially under Navy contract demonstrate simplicity and accuracy of these new components. The navigational instrument—no larger than a demitasse cup—operates on the inertia principle. Once started in motion in one direction, it "remembers" its original course and instantly senses directional changes in three dimensions. Any change in direction of movement causes measurable change in current output and this in turn activates proper control devices.

Thermostat Control: An electrochemical unit has been developed at NOL to control furnace and room temperatures. The instrument detects rate at which given temperature change is taking place, rather than sensing that change has already occurred. Tendency to overshoot or undershoot desired temperature range is eliminated. Unit can be made sensitive enough to retract to heat of human body, to practically any light source in its vicinity, or to mild pressure.

Sound-Sensitive Meter: Sound - exposure meter for measuring cumulative exposure of personnel to jet engine noise is also being developed by the Navy. Fluid in the electrochemical unit gets darker as it is exposed to high-intensity sound. Person wearing the meter is warned when color indicates exposure to a predetermined amount of sound.

flow signals may be fed from unit to unit like currents and voltages are fed through electronic networks. In addition to simple amplification, several mathematical operations may be carried out upon the original incident signal or signals in this manner: for example, products, ratios, derivatives, etc., may be obtained.

The simplest and most reliable method of carrying out this reverse effect is by the use of electro-osmosis, a process involving the movement of liquid with respect to a fixed solid (e.g., a porous diaphragm or a capillary tube) as a result of an applied electric field. An electro-osmotic cell, Fig. 6, consists of a fritted-glass disk dividing a cell into two compartments, with electrodes on each face of the disk. Operating characteristics can be made to vary over extremely wide ranges by control of disk porosity, thickness, and diameter, choice of working liquid, etc. The important point, however, is that fluid flow produced by an applied voltage is linear with the value of voltage.

Fluid flow for a 30-mm diameter, 20-mm thick disk of this type is in the neighborhood of 10^{-3} cm^3/sec at 1 volt applied to the electrodes. A flow rate of 10^{-5} cm^3/sec through a separated detector, Fig. 5, will yield some 100 microamperes output, so that the values of flow rate produced by the electro-osmotic cell easily cover the working range of the other electrochemical units.

Power gains in the order of 330 may be obtained by combining these electrochemical units with the electro-osmotic cell with a linearly operating separated detector.

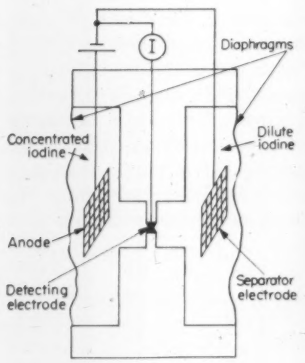


Fig. 5—Seperated solion detector designed primarily for measuring dc flows and pressures. Units of this design have been constructed with sensitivity of 1 dyne/sq cm.

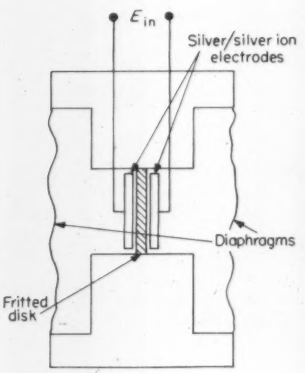


Fig. 6—Electro-osmotic cell for converting electrical energy in fluid flow. Units have been designed that fit into working range of separated detectors.

Solion Development Timetable

Various forms of solions have been developed over the past 10 years at the Naval Ordnance Laboratory in collaboration with scientists at the Defense Research Laboratory at the University of Texas.

Basic development thinking really started back in 1941 when Dr. David S. Muzzey, while employed at the Shell Oil Co. and now with NOL, conceived the idea of using an electrode in solution for acoustic and pressure transducers, such as geophones, accelerometers, etc. He performed basic studies required to show the feasibility of this conception.

During World War II further feasibility studies, aimed toward ordnance applications, were conducted at NOL by Messrs. Cohen and Root. In the course of this work it was demonstrated that an iodine-iodide system appeared sufficiently reversible for use in ordnance devices. To date, no better universal system has been found. U.S. Patent Number 2,685,025 was issued in 1954 to Mr. Root on some of his work.

In 1947, NOL began a concerted effort, under the direction of Mr. Nelson N. Estes, to apply the results of this early work to specific ordnance devices. A number of basic application problems arose in the preliminary studies. These were classified in order of importance and, from 1949 on, were studied jointly by research personnel at NOL and Messrs. R. M. Hurd and R. N. Lane at the Defense Research Laboratory of the University of Texas. Auxiliary studies at NOL showed the then new plastic material Kel-F to be ideally suited for iodine-iodide systems.

In 1951, NOL and the Emhart Mfg. Co. of Hartford, Conn., began studying techniques for molding this relatively new material into the complex forms required while preserving the rigid purity and exacting dimensional requirements. By 1953 this company was engaged in manufacturing small quantities of solions for experimental ordnance devices. Emhart is producing solions in quantity for the U.S. Navy.

How to select and apply

PRESSURE SWITCHES

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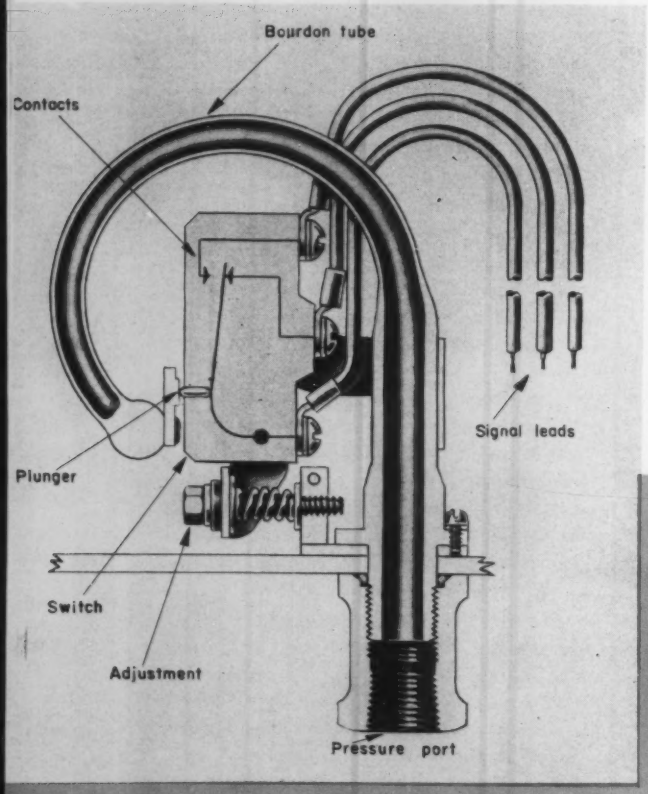


Fig. 1—Typical Bourdon-tube pressure switch. Pressure introduced at the port draws the tube away from the snap-action switch and actuates the contacts. No separate load spring is required in this case because of the high spring rate of the Bourdon tube.

INITIATION of control action in response to a pressure change is the design function of a pressure switch. In many cases, fluid-system pressure is the parameter that is under direct control by the switch. An example is modulation of pump output pressure. In other applications, pressure signals detected by the pressure switch are simply indirect evidence of change in another system parameter. For example, flow rate, volume and temperature are often represented by analogous pressures.

Purpose of the pressure switch may be relatively simple. A familiar example is use of the switch to signal application of pressure in an automobile brake system by completing the circuit to the stop lights. Or, in a more elaborate installation, the pressure-switch may be merely the first link in a

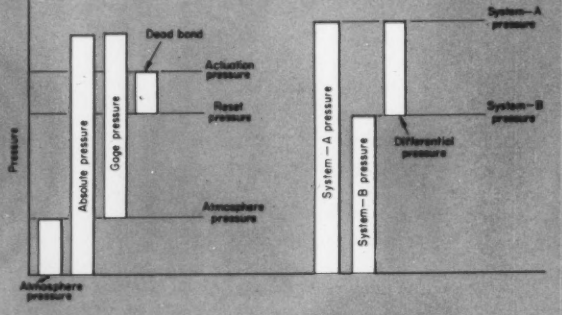


Fig. 2—Comparison of pressures measured by absolute, gage and differential-pressure switches.

Pressure-Switch Check List

1. Does the pressure switch control an inductive, lamp, or heater-load circuit?
2. Is system pressure steady-state or pulsating? What is the magnitude of pressure pulses near the actuation-pressure point?
3. Does the pressure switch control an impulse-generating device such as a solenoid valve?
4. Will the pressure switch be subjected to changing atmospheric pressures? In what way will this affect system absolute pressure? Gage pressure?
5. Will the pressure switch be subjected to vibration? If so, will it be detrimental to pressure-switch operations?
6. Will the pressure switch be subjected to extreme temperatures? Temperature variations?
7. Will the sensing element be exposed to corrosive fluids?
8. Will the pressure switch be exposed to the natural elements?

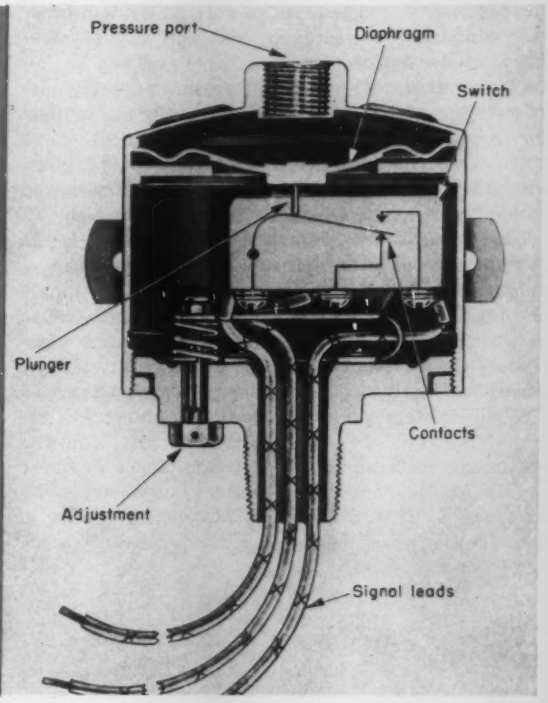


Fig. 3—Presssure switch with diaphragm sensing element. Unit is for controlling gage pressure in a low-pressure system. No load spring is employed.

complex chain of electronic or electromechanical control components. In this article, emphasis centers on selection and application of the pressure switch. Associated mechanical and electronic devices are examined here only to the extent that they form primary working parts of the basic switch.

In pressure-switch selection, it is found, typically, that no universal design best satisfies the demands of all applications. A switch designed for high response rate—say, for an instrumentation system—may be found entirely unsatisfactory in an aircraft hydraulic system. In following sections, a cross-section of the various pressure-switch types available to the designer is presented, and the relationship of system characteristics to switch selection is examined.

▶ Pressure-Switch Anatomy

Three functional part groupings make up the conventional pressure-switch: (1) the pressure-sensitive element, which is a Bourdon tube, diaphragm or piston, (2) the load spring, and (3) the electrical-contact assembly, usually of snap-action design.

Sequence of operation in a pressure switch starts with application of pressure to the sensing element, Fig. 1. Best element for use depends upon

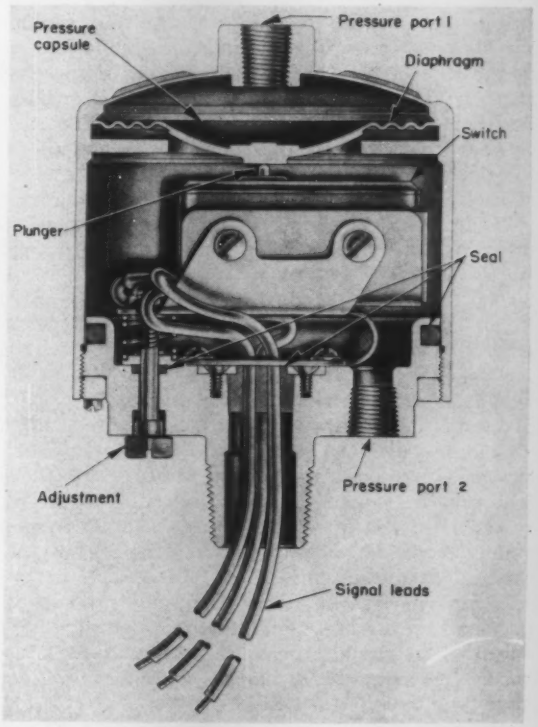


Fig. 4—Differential-pressure switch with diaphragm sensing element. Unit can be converted to absolute type by first sealing and then evacuating the switch housing by means of a vacuum source connected to port 2.

the sensitivity, ruggedness, accuracy, system-pressure range, life expectancy, cost and size requirements of the application.

Opposing movement of the pressure-sensing element is the load spring, which is usually adjustable. Obviously, the pressure element will not move until system pressure has increased to the point where the spring preload is overcome. Varying the preload varies the actuating point of the element.

Mechanically linked to the sensing element is the contact assembly, which can be in any arrangement: single or multiple pole, single or double throw, single or multiple circuit, or a combination of these basic types. Contact actuation, by completing the external connected circuit, initiates the control action desired from the pressure switch.

When system pressure decays, contacts are reset. Because of mechanical hysteresis, contact-movement differential and friction, reset pressure is always at some finite value below actuation pressure. This pressure difference, as noted in the Glossary, is defined as the pressure-switch dead band.

▶ Three Basic Types

Pressure switches are designed in three basic types: (1) gage, (2) differential, and (3) absolute. Comparison of the pressures measured by these switches is given in Fig. 2.

Gage Type: By far the most common pressure switch is the gage type, Fig. 3. In this switch, one side of the pressure-sensing element is ported to the system pressure; the other side of the element is vented to the surrounding atmosphere. The element responds, therefore, to the difference between the pressure in the system connected to the pressure-sensing port and the ambient atmospheric pressure.

If the load spring is adjusted for 5 psig actuation pressure, for example, it will actuate at 19.7 psia at sea level (p_s = 14.7 psi). At an altitude of 60,000 ft (p_s = 1.07 psi), it actuates at 6.07 psia. In an aircraft system where the pressure switch may be used to control fluid pressure to within a few psi of vaporization pressure, a gage-type switch would be unusable since system pressure would be allowed to drop below vaporization pressure at high altitudes. On the other hand, if the pressure switch is required to control pressure within a few psid of system burst pressure, a gage-type switch is mandatory since it can maintain a constant differential pressure between the system and the ambient atmosphere at all altitudes.

In airborne systems where actuation pressure is in the magnitude of several hundred psig or greater, variation in absolute pressure with altitude is so small (percentagewise) as to be negligible. A gage-type pressure switch is therefore suitable for such applications.

Differential Type: The differential-pressure switch has two pressure-sensing ports, Fig. 4. The high-pressure port, plumbed to the higher of two system pressures, is connected to one side of the pressure-sensing element. The low-pressure port is plumbed to the lower of the two system pressures and is connected to the other side of the sensing element. The single-acting sensing element is most common in differential-pressure switches. Occasionally, however, a double-acting element is used.

With the single-acting element, pressure-sensing ports are not interchangeable. This type of pressure switch is used when it is known that the higher pressure will always occur at the high pressure port, or that no actuation is required when the higher pressure is applied to the normal low-

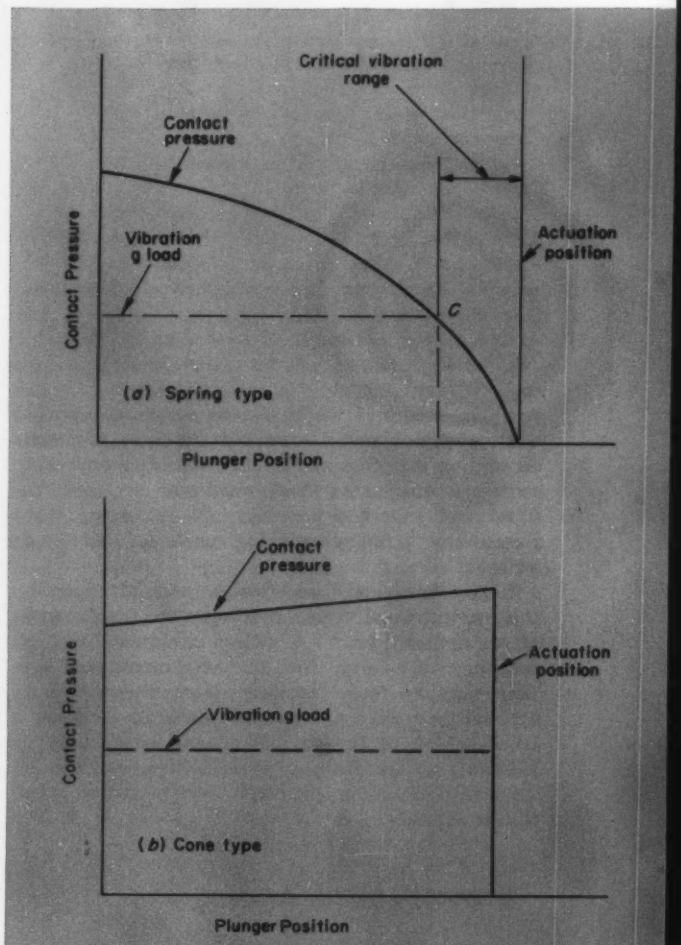


Fig. 5—Contact pressure as a function of plunger position for spring-type contact assembly, *a*, and cone-type contact assembly, *b*. With spring-type contacts, chatter begins at point *C* in response to the vibration *g* load. Chatter continues until actuation pressure is reached. With cone-type contact assembly, contact pressure increases steadily with plunger travel, and no critical vibration range exists.

pressure port. When it is possible for a higher pressure to occur in either of the two fluid systems, and it is essential for contacts to actuate when either system has the higher pressure, then a double-acting pressure-sensing element must be used.

If the load spring (or double-acting spring assembly) is adjusted for 5 psid, for example, then a differential pressure of 5 psid will obviously actuate the contacts if the system pressures are zero and 5 psig, 10 and 15 psig, 25 and 30 psig, or 1000 and 1005 psig. The only limiting factor is the structural strength of the pressure switch and the possible variation of mechanical or frictional hysteresis with pressure level.

Absolute Type: The absolute-pressure switch, like the gage type, has a pressure-sensing port connected to one side of the pressure - sensing element. The other side of the element is exposed to a vacuum, Fig. 4. If the load spring is adjusted, for example, for 5 psia actuation pressure, contacts are actuated when 5 psia is applied, regardless of ambient atmospheric-pressure level. With the pressure port vented to the atmosphere, a properly adjusted absolute-pressure switch can be set to actuate at any desired altitude.

Since the absolute actuation pressure does not vary with altitude, it is apparent that the pressure differential between the controlled fluid system and the ambient atmosphere will vary. If, for example,

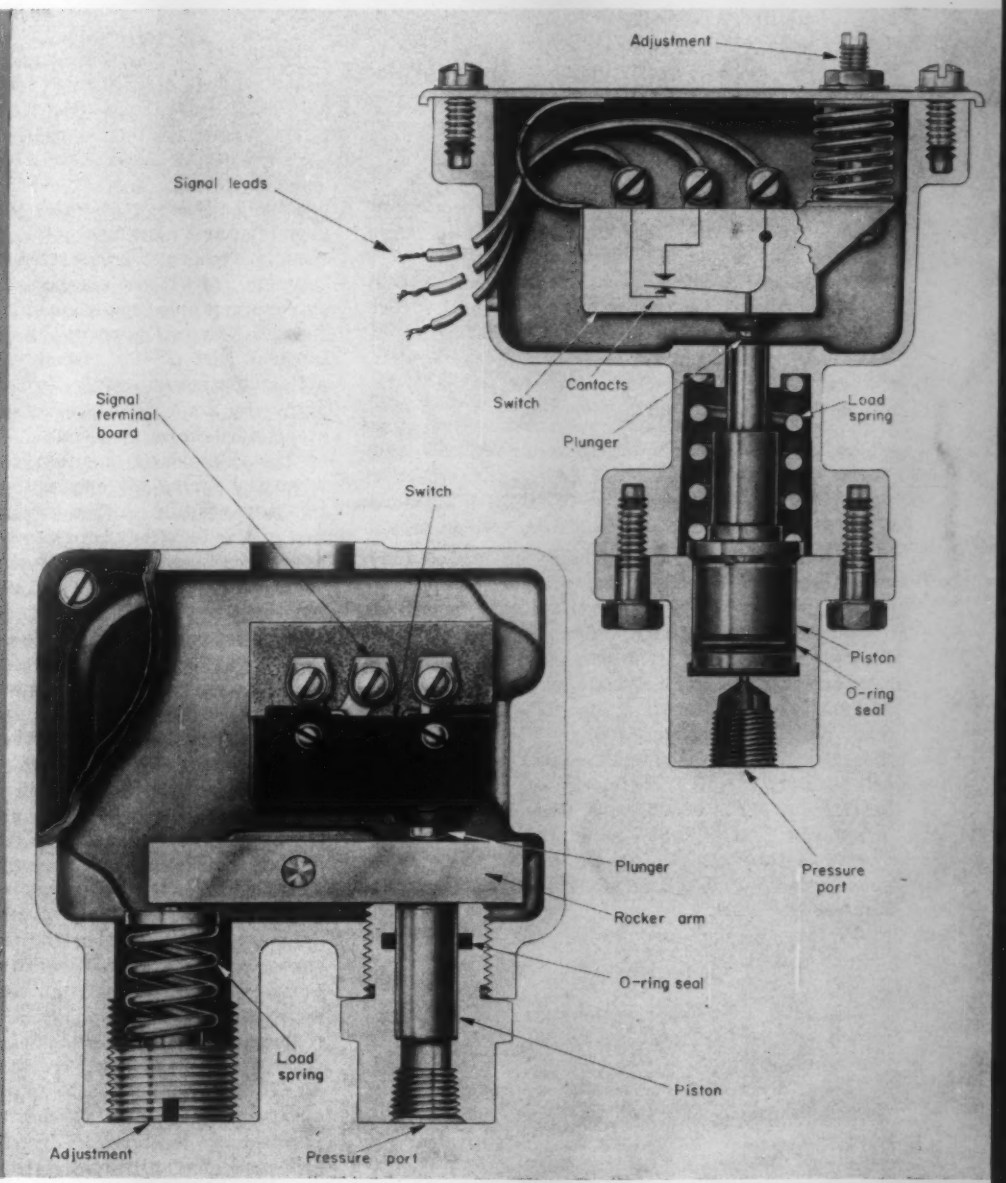


Fig. 6 — Piston-type gage-pressure switches.

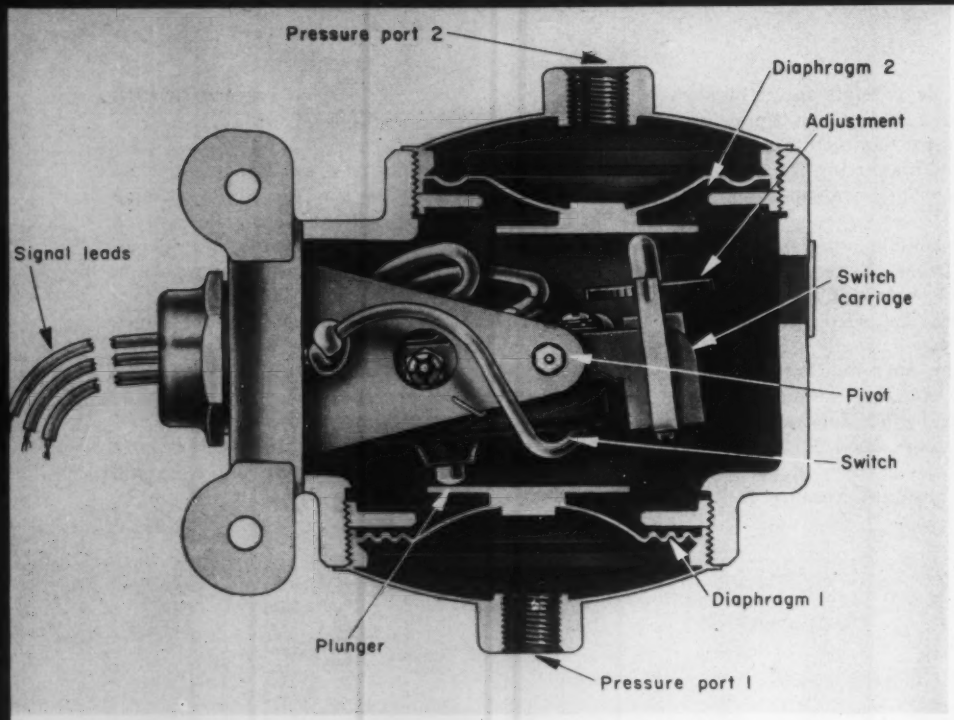


Fig. 7 — Double-diaphragm differential-pressure switch, often used where contact with the system fluid is detrimental to the electrical contacts of the switch. Pressure applied to port 1 deflects the diaphragm against the switch plunger. An equal pressure applied to port 2 (zero pressure differential) rotates the contact assembly about the pivot and draws the plunger away from diaphragm 1.

the load spring is adjusted for 20 psia actuation pressure and the fluid system has a 10 psid burst pressure, the system is safe at standard sea level where the differential pressure between system and atmosphere is approximately 5 psid. At 60,000 ft, however, the differential pressure is, in this case, approximately 19 psid, and the system will rupture. An absolute-pressure switch could not be used in such an application.

▶ Selecting the Pressure Switch

Pressure switches are normally identified only with respect to electrical and pressure rating and type. Seldom are they identified with regard to response rate, sensitivity, calibration drift, or vibration resistance. Of two different pressure switches of identical electrical and pressure ratings, one may be suitable for a specific application, the other completely unsatisfactory. It is necessary, therefore, that the system designer select a pressure switch not only for electrical and pressure rating, but with regard to the suitability of all component parts that make up the pressure-switch assembly. For each of the three basic elements of a pressure switch—contacts, pressure-sensing element and load spring—there is a basic type most suited to the special demands of the application.

Contact Assemblies: By function, the pressure-switch contact assembly is available in either of two basic designs: direct action or snap action.

DIRECT-ACTION CONTACTS: Movement of direct-action contacts occurs as a linear function of pressure-sensing element movement. They are usually of simple design and, consequently, are least expensive. However, because of the possibility of slow contact movement, for example, when the sensing element is pressurized slowly, direct-action contacts are subject to excessive arcing. This is an unacceptable condition in most installations.

SNAP-ACTION CONTACTS: A plunger, which is an integral part of the assembly, actuates the snap-action contact assembly. Contacts are held together by a spring that reverses its force direction at an over-center position. The spring is moved to the over-center position by the plunger and, when the spring force reverses, contacts snap into the new position. One advantage of this design lies in the fact that contacts cannot be repeatedly opened and closed by small sensing-element pulsations as is the case for direct-action contacts. Another advantage is that snap-action contacts move very quickly from full-closed to full-open position with no lingering between. Arcing, therefore, is reduced to a minimum.

Snap-action contacts are available in two basic modifications: the over-center spring type and the over-center cone. Each modification has its own merits. The spring type usually has a much lower actuation-force and movement-differential requirement. It also has the disadvantage of having steadily decreasing contact pressure during plunger movement before snap-over occurs. This problem is critical only if contacts are vibrated during actuation. If vibration is present, then spring contacts start to chatter as soon as contact pressure becomes less than the g load exerted by environmental vibration.

The cone-type snap-action contact assembly characteristically increases contact pressure with plunger movement until snap-over occurs. Main disadvantage of this assembly is that it usually requires a considerably greater actuation force and movement differential than other types. An

additional handicap is that cone contacts occasionally hang up on the cone, acting like direct-action contacts.

Relative contact pressures as a function of plunger travel for over-center spring and cone-type snap-action contact assemblies are shown in Fig. 5.

Sensing Elements: Selection of the pressure-sensing element is the next consideration. Three basic designs are available: Bourdon tube (including variations such as the *B* type), diaphragm (including the bellows), and piston.

BOURDON ELEMENT: The Bourdon tube, Fig. 1, is perhaps the oldest and most widely used pressure-sensing element for pressures over a few hundred psig. It has the advantage of simplicity of design and a high frequency-response rate. The tube responds to pressure impulses of shorter duration than any other sensing element. Although high sensitivity is desirable in many applications, the Bourdon may require compensatory measures in systems where pump ripple exists or impulses occur. Because of the unsupported tube mass, the Bourdon tube is also more sensitive to vibration than other sensing-element designs. Furthermore, because of its configuration, it may be more subject to calibration drift with temperature change than other elements. In many applications where pressure pulsations, vibration, and temperature changes are not severe, the Bourdon tube, because it is leakproof and simple in design, is the best sensing element.

PISTON ELEMENT: The piston sensing element usually incorporates a seal such as an *O*-ring, Fig. 6. These seals may sometimes leak because of wear in service or damage during assembly. An important advantage is that the piston has a self-damping effect which reduces switch response to pump ripple or system impulses. Because of close dimensional coupling of parts, the piston displays relatively low calibration drift with temperature changes. However, unlike the Bourdon tube, the piston must have a separate load spring which may sometimes be subject to calibration drift with temperature changes unless the pressure-switch housing is designed to compensate the drift. Piston-seal friction has a tendency to increase the pressure-switch dead band, and this effect is most noticeable at very low temperatures. Seal friction makes the piston pressure-sensing element impractical for low-pressure application, and diaphragm-type elements are generally more satisfactory for such service.

DIAPHRAGM ELEMENT: The diaphragm pressure-sensing element, Fig. 7, is used in low-pressure applications because of its large effective area and low hysteresis. Few high-pressure diaphragm elements are available since, when the diaphragm is made heavy enough to withstand the pressure, it often has a tendency to work harden with use. This work hardening changes the pressure-switch calibration.

Diaphragms are made from many materials. Most common are: stainless steel, beryllium copper, Teflon-impregnated glass fiber, and rubber or synthetic-rubber compounds. Metal diaphragms are often used without a separate load spring, the diaphragm itself having a high enough spring rate. Metal diaphragms, however, are subject to cracking and/or spring rate change if exercised excessively. Rubber and synthetic rubber-compound diaphragms, while having nearly constant spring rate, age and deteriorate in service. Teflon-impregnated glass fiber diaphragms will not change spring rate or deteriorate with age, but are subject to minute leaks. Fortunately, leaks are so slow that most liquids evaporate faster than they migrate through the diaphragm.

Load Springs: Last basic element requiring consideration in pressure-switch selection is the load spring. Although there are many varieties, the springs most commonly used are the helical and Belleville types. Spring rate, buckling, and preload are important load-spring performance considerations. These factors, however, are switch design rather than selection problems and therefore are not discussed here.

The important difference from a performance standpoint between helical and Belleville springs is found in their load curves. The helical spring has a linear load curve while the Belleville spring has a nonlinear curve that provides a negative rate throughout a small portion of the spring travel. This negative-rate region gives the Belleville spring a snap action. Fig. 8 shows that the slope of the Belleville load curve is initially positive, becoming negative for a finite displacement after the apex. At the valley limit, it again assumes a positive value. Since the spring is displaced by the pressure-sensing element, which in turn is displaced by fluid pressure, as soon as the

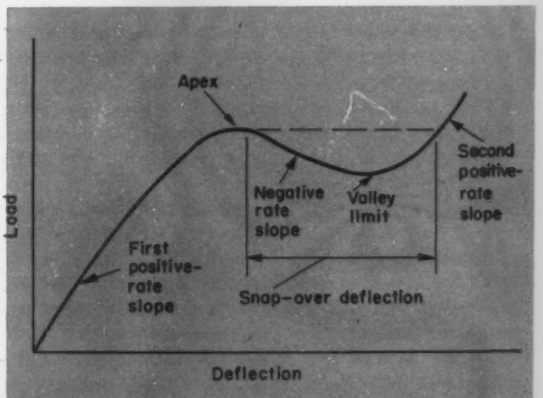


Fig. 8—Load vs. deflection characteristics for Belleville spring. Since volume of the fluid-pressure sensing element changes only slightly with deflection of the spring, pressure reduction in the element accompanying its movement is negligible. Pressure remains substantially constant, therefore, as snap-over occurs.

apex is reached, more pressure than necessary for further spring displacement is being applied. Result is that the sensing element snaps the spring over to a position on the second positive slope nearly equal to apex pressure.

The Belleville spring has other advantages over the helical spring: (1) lower dimensional height, giving smaller calibration change with temperature, (2) smaller size, and (3) lower weight.

System Characteristics: Fluid-system characteristics often influence the choice of best pressure switch for an application. For example, the method of system pressurization is of great importance, since it determines the steadiness of the established pressure.

To illustrate two extremes in system pressurization techniques, comparison is made between a static system pressurized by a hand pump and a dynamic system pressurizied by a piston pump. The hand-pump system displays a straight-line pressure rise, with level steps occurring between each pump stroke, Fig. 9*a*. The maximum pressure delivered by the hand pump is the pressure felt by the system components. With a piston pump, in contrast, the pressure rise assumes a sine-wave curve, Fig. 9*b*. System pressure is an average of the sine-wave extremes. How this phenomenon reduces the effective dead band of the pressure switch when its sensing element has a frequency response as fast or faster than the pump ripple pulses is also illustrated in Fig. 9*b*. If dead band is a critical factor, then a Bourdon-tube sensing element is least satisfactory, and an inherently self-damping piston element is recommended.

Another system characteristic that illustrates the need for a reasonable dead band is illustrated when a rapidly closing valve interrupts a flowing system. Assume that a pressure switch controls a solenoid valve that closes when system pressure drops to a specified value. That is, as pressure decays, the pressure switch operates the solenoid valve by resetting the contact assembly.

When the valve closes, a surge is induced which rises above the pressure-switch actuation pressure and causes the solenoid valve to reopen, Fig. 10. As soon as the valve opens, system pressure again decays, and the valve closes again. This induces another surge, and the whole process repeats until the system is shut off.

A third system characteristic that must be considered in pressure-switch selection is pump-flow rating versus demand. Assume that the pump is driven by a motor controlled by a pressure switch, and that demand is almost equal to pump plus accumulator capacity. The pressure switch then repeatedly starts and stops the motor unless the pressure-switch dead band is broad enough to allow the pump to over-charge the accumulators by a reasonable amount. Another solution, of course, is to add accumulator capacity to the marginal system.

The final factor requiring consideration in selection of a pressure switch is ambient environment. Vibration is probably the most critical factor. If

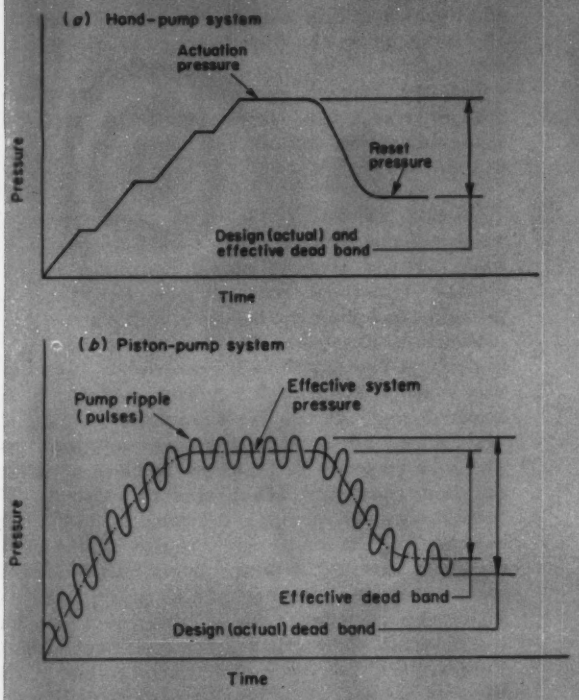


Fig. 9—Pressure vs. time compared for hand-pump and piston-pump pressurized systems. Steps on the rising portion of the hand-pump system curve, *a*, represent pauses between pump strokes. In this system, the effective dead band equals the design dead band. Dashed line in the piston-pump system, *b*, represents the effective system pressure. If the sensing element has a response time equal or faster than the pulse rate, contacts actuate at the extremes of the pressure-pulsation sine waves. However, since effective system pressure is the average of pressure pulsations, the effective dead band is less than the design dead band of the pressure switch.

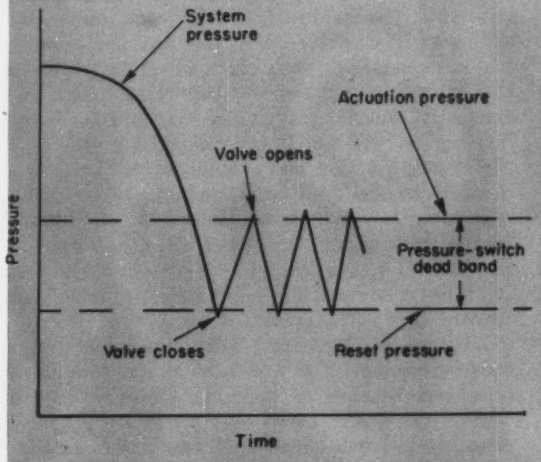


Fig. 10—Impulses induced in a fluid system by a pressure-switch controlled shut-off valve. Surge illustrated is of greater magnitude than the pressure-switch dead band. If the dead band were larger, the rising pressure surge would not reach actuation pressure, the valve would remain closed, and the surge would dampen out.

the pressure switch contains spring-type snap-action contacts, then contacts start to chatter when contact pressure is less than the *g* load of vibration. One solution to this problem lies in the use of a cone-type contact assembly, assuming that existing actuation forces permit.

Another solution leads to the use of a Belleville load spring with the contact assembly adjustable so that the critical portion of the contact actuation curve falls within the "snap" portion of the Belleville curve, Fig. 11. Such a configuration prevents lingering of the contacts in the critical portion of their curve and produces a vibration-proof pressure switch.

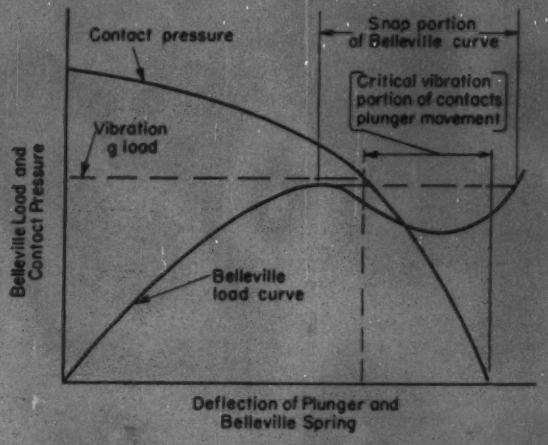

Contact pressure
Snap portion of Belleville curve
Critical vibration portion of contacts plunger movement
Vibration g load
Belleville Load and Contact Pressure
Belleville load curve
Deflection of Plunger and Belleville Spring

Fig. 11—Use of Belleville spring to snap the contacts plunger through its critical-travel range.

Another environmental condition requiring consideration is temperature, since extreme temperature changes alter pressure-switch dimensions and frictional hysteresis. These factors, in turn, affect pressure calibration and dead band. When ambient temperature varies over a wide range, then functional parts of the pressure switch should be dimensionally close-coupled. Sliding seals should be avoided where possible, as well as other elements that may be affected by temperature variation.

For aircraft pressure switches, the effects of atmospheric pressure changes accompanying altitude changes must be considered in light of pressure-switch duty requirements discussed previously.

If the pressure-switch is not a completely sealed unit, then the effects of the natural elements on working parts must also be considered. The Bourdon-tube pressure switch resists exposure to water, dust, and ice better than either the diaphragm or piston-type units.

A final environmental factor in switch selection is its explosion excitation potentiality in an explosive mixture. The safest solution to this problem is a completely sealed unit.

▶ Typical Applications

To illustrate the pressure-switch selection procedure, two hypothetical systems are presented. Fig. 12*a* is a schematic diagram of a simple fluid system. It consists of a charged bottle, a valve,

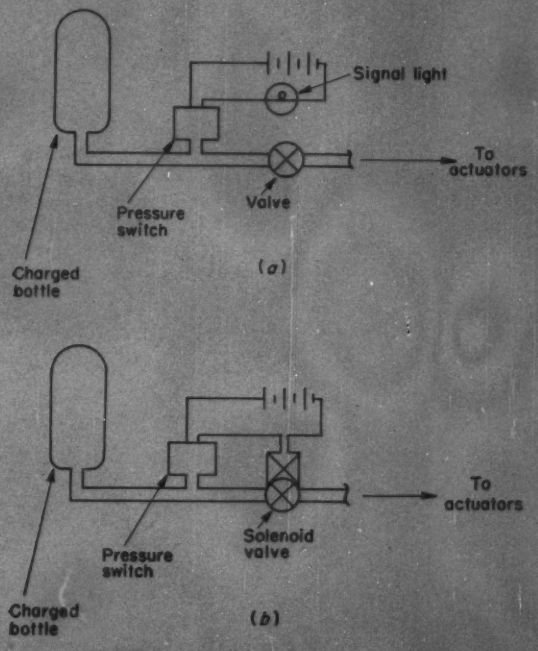


Fig. 12—Representative pressure-switch applications. In system *a*, pressure switch operates a signal light to provide warning of low bottle pressure. System *b* illustrates application of pressure switch to control a solenoid valve at a specified low pressure.

GLOSSARY

Actuation pressure: Rising pressure at which electrical contacts reverse zero-pressure position. If, at zero pressure, contacts are closed, they will open at actuation pressure.

Reset pressure: Decaying pressure at which electrical contact resume zero-pressure position.

Dead band: Pressure difference between actuation and reset pressures.

Impulse or Surge: Sudden momentary rise in system pressure, such as might occur when a valve closes rapidly under high-flow conditions.

Pump ripple: Continuously repeated, momentary system-pressure rises caused by the pumping action of a piston pump. Frequency of pulsation is a function of pump speed times number of pump pistons.

Contact assembly: An assembly containing contacts, load spring for contact pressure, and a plunger actuator. A term used in this article instead of the term "switch." This is to avoid confusion with the term "switch" meaning the *complete* pressure-switch assembly.

Contact-movement differential: Physical difference between contact plunger position at actuation and at reset.

Contact chatter: Continuous, rapid opening and closing of electrical contacts. Usually caused by vibration or pressure pulsations.

Calibration: Adjusted value of actuation pressure.

psi: Pressure in lb per sq in. with no reference base specified.

psia: Pressure in lb per sq in., absolute. Reference base is a complete vacuum.

psig: Pressure in lb per sq in., gage. Reference base is the ambient atmosphere.

psid: Pressure in lb per sq in., differential. No reference base specifield. Applies to the differential pressure between any two system pressures.

an actuator and a pressure switch wired to a signal light. The system is considered earth-bound and is not subjected to vibration or extreme temperature changes.

If the duty of the pressure switch is simply to warn the operator, via the signal light, that bottle pressure is low, any combination of pressure-switch basic parts suffices. Furthermore, the contact assembly need not be snap-action, no compensation for pressure pulsation or surge need be applied, no specific dead band is required, and no vibration resistance need be provided. For such an application, a Bourdon-tube sensing element is simplest and no load spring is required.

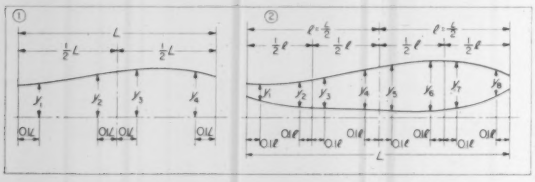
A more complex system, where the valve is solenoid-operated under the control of a pressure switch is shown in Fig. 12*b*. The contact assembly in this case is preferably of the snap-action type. In such an installation, contact movement differential should be high enough to provide a dead band of greater width than the surge caused by the closing valve.

Similarly, if a piston pump is added to the system, either a wider dead band is required, or the Bourdon tube can be replaced by a piston-type sensing element that dampens out the effects of pump ripple. If such a system is subjected to severe vibration, the best sensing element is the piston type, and the load spring that gives negligible contact chatter is the Belleville type.

Tips and Techniques

Calculating Areas

The following approximate method for calculating irregular areas will give quite accurate results. When the area to be calculated is symmetrical



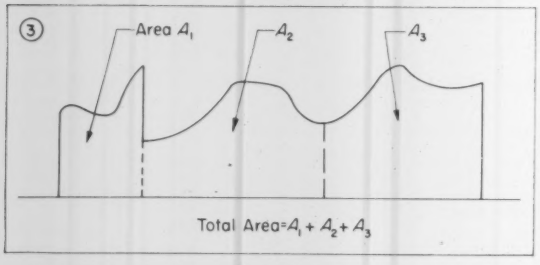
about a center line, first draw the center line. Then measure the heights of four ordinates located as shown in sketch 1. Area, A, is then

$$A = 2\left(\frac{Y_1 + Y_2 + Y_3 + Y_4}{4}\right) L$$

When the area is not symmetrical about a center line, sketch 2, or higher accuracy is required, use of eight ordinates is recommended. When using eight ordinates as shown,

$$A = \left(\frac{Y_1 + Y_2 + Y_3 + \ldots + Y_8}{8}\right) L$$

These equations are for use on any area bound-

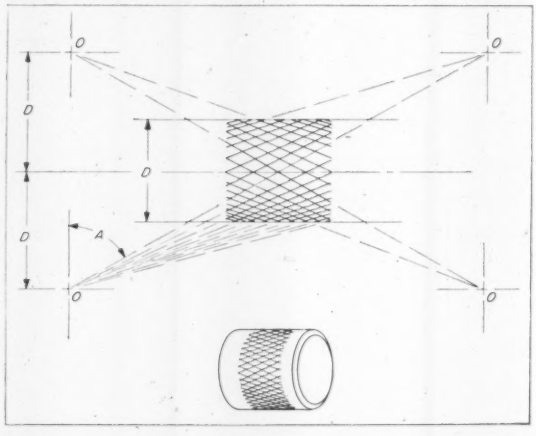


ed by curves having no breaks in the contour and having not more than three maximum or minimum points. When these occur, the area should be broken up into separate sections, sketch 3, and each section figured separately.

The maximum error when using four ordinates per section is approximately 1.5 per cent. Error when using eight ordinates is of course, even less. —M. D. KORKUT, *Avondale Marine Ways Inc., Harvey, La.*

Drawing Knurls

Cylindrical knurls can be drawn in a pictorial or perspective drawing by a simple method that produces a pleasing effect. The technique consists of using four "vanishing" points, O, two on each side of the cylindrical surface. The angle, A, should

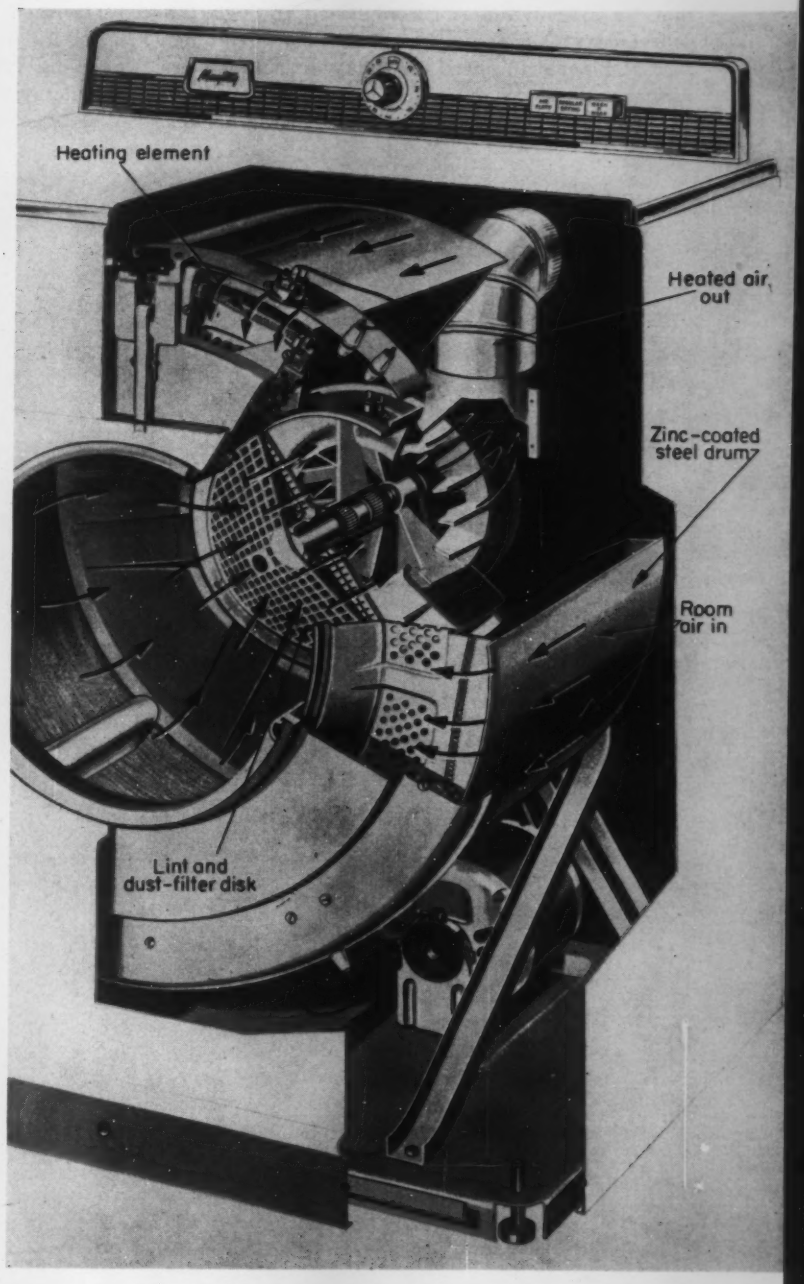


be the angle of knurl desired, usually either 30 or 45 degrees. Points O are located one diameter, D, from the centerline of the part. The radial lines from the vanishing points are drawn closer together as they approach the sides of the cylinder. The spacing can be judged visually to produce a pleasing appearance.—M. MIGATZ, *Brach Mfg. Co., Newark, N. J.*

Suction Air-Flow System Permits Dryer to Double as Vacuum Cleaner

Unique heating and air-flow design principles employed in the new Maytag dryer provide uniform drying heat through the clothes and, at the same time, convection cooling of cabinet. If the air-fluff button is pushed, the machine not only can fluff such items as towels, terry-cloth garments, etc., but it can also shake and vacuum dust from rugs, bedspreads, curtains, etc. The air-fluff button cuts off the heating element. A suction air-flow rate of 150 cfm removes dust quickly. The dust material is trapped in a disk-shaped, removable filter mounted at the air outlet in the center of the revolving drum.

In operation, a suction fan pulls room air through slots in the rear of the cabinet and draws it to the front of the dryer across the complete outside surface of the revolving drying drum. This moving blanket of air insulates drum heat from the cabinet. The warm drum also serves to preheat the drying air, which enters the front of the drum through perforations in a shield behind heating coils.

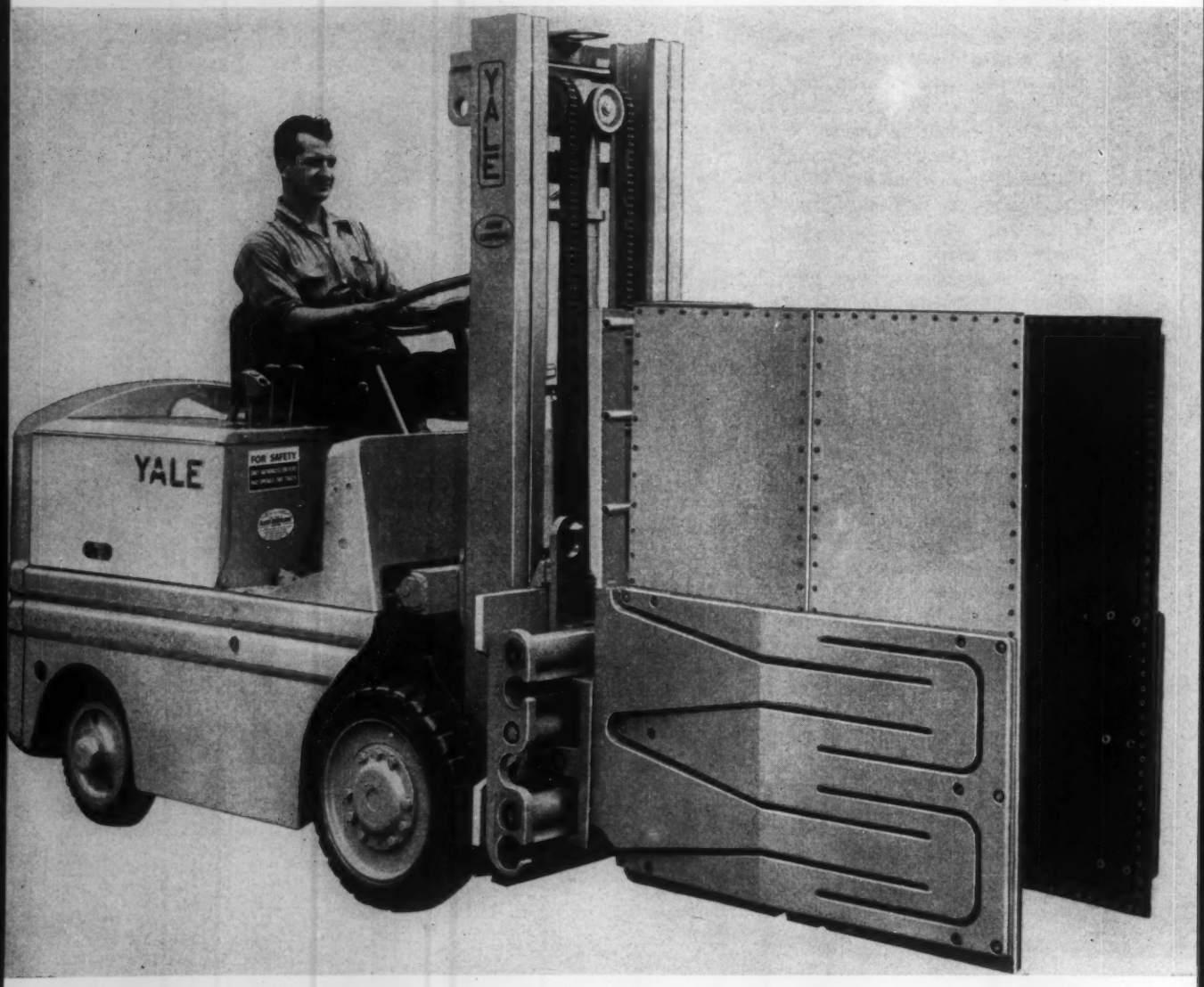


Hydraulically Operated Leaf-Spring Clamp

Carton clamp developed by the Yale and Towne Mfg. Co. features a new narrow-arm design which permits closer stacking of cartons and better utilization of storage space. The clamp is unique in that its articulation is accomplished through the deflected-metal construction of the arm. This design eliminates the need for bulky articulation arrangements on the outside of the clamp arm.

Clamp and clamp pads are made of aluminum. The actual clamping surface is rough-top rubber bonded to a thin metal sheet which is attached to the aluminum pad. This design provides excellent pressure distribution on the load.

Operated hydraulically, the clamp controls are normally arranged with three pressure settings for handling various types of carton loads. The hydraulic system can be set up for a higher number of settings, if this is desired.



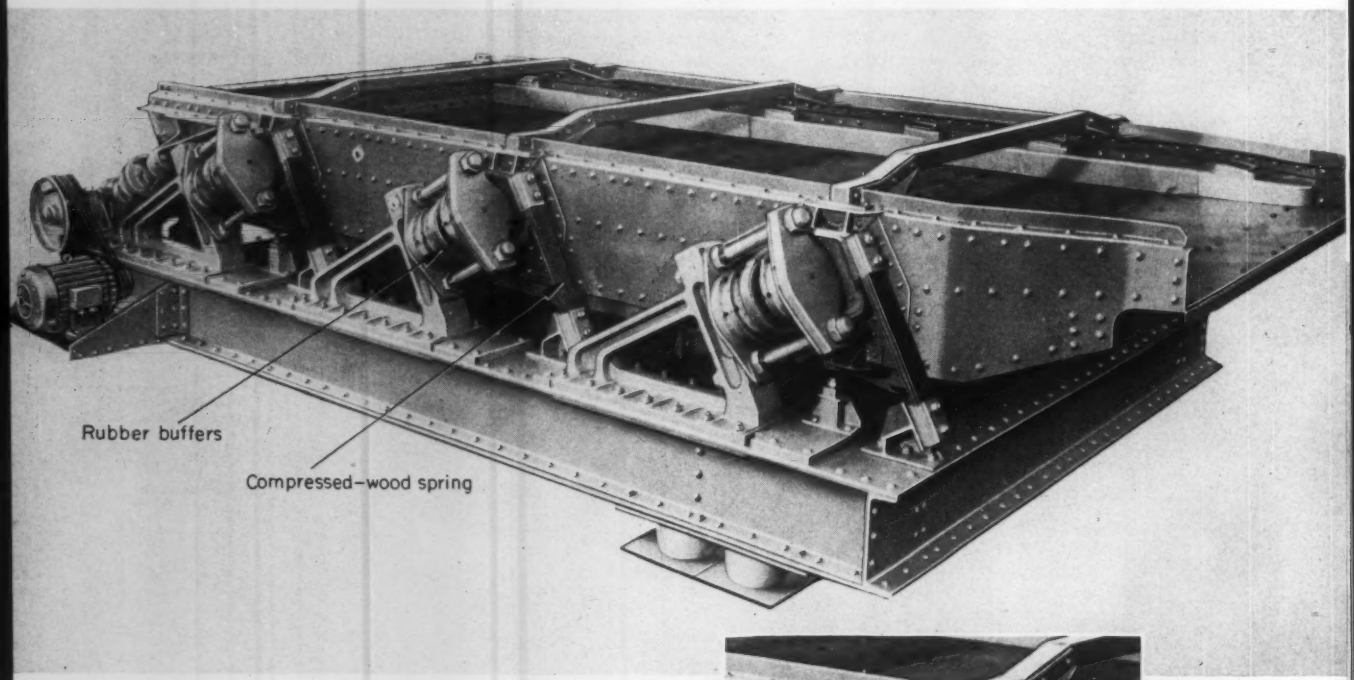
TV Set Fits in Corner and Is Controlled by Sound

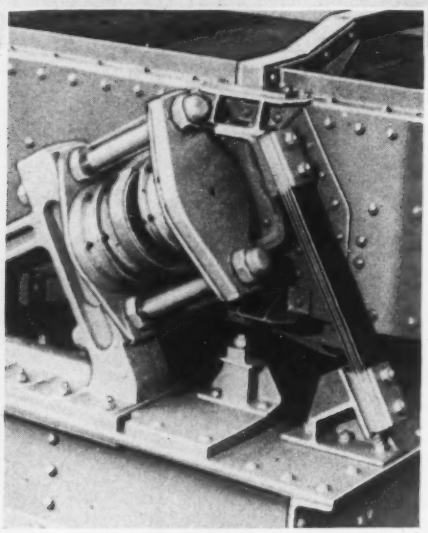
New Motorola console television receiver is designed to fit close to walls in room corners. Built with a 21-in. picture tube, the model 21V1 has a completely finished back permitting it to serve also as an L-shaped room divider.

A wireless remote-control device serves to turn set on and off, change channels, and control volume. Called the Golden Satellite, the remote unit operates the receiver by transmitting supersonic sound waves which are electronically generated by a transistor-powered magnetostrictive transducer. Practical operating distance is 40 ft.

Tube Sentry design feature eliminates surge of starting power to tube filaments and delays application of plate power voltage until tubes are sufficiently heated. Special tubes and the Tube Sentry feature increase expected tube life four times as compared to previous models.

Wooden Springs and Rubber Buffers Combined in High-Efficiency Vibrator

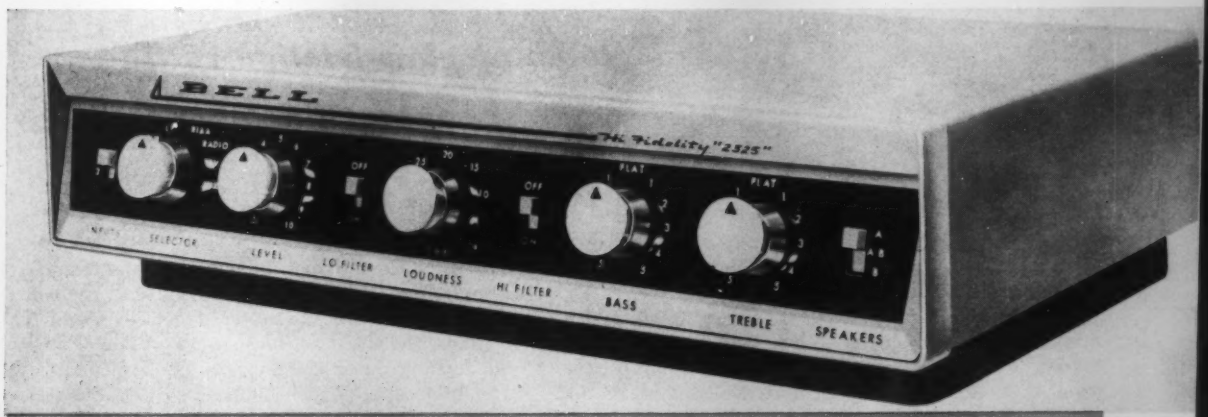


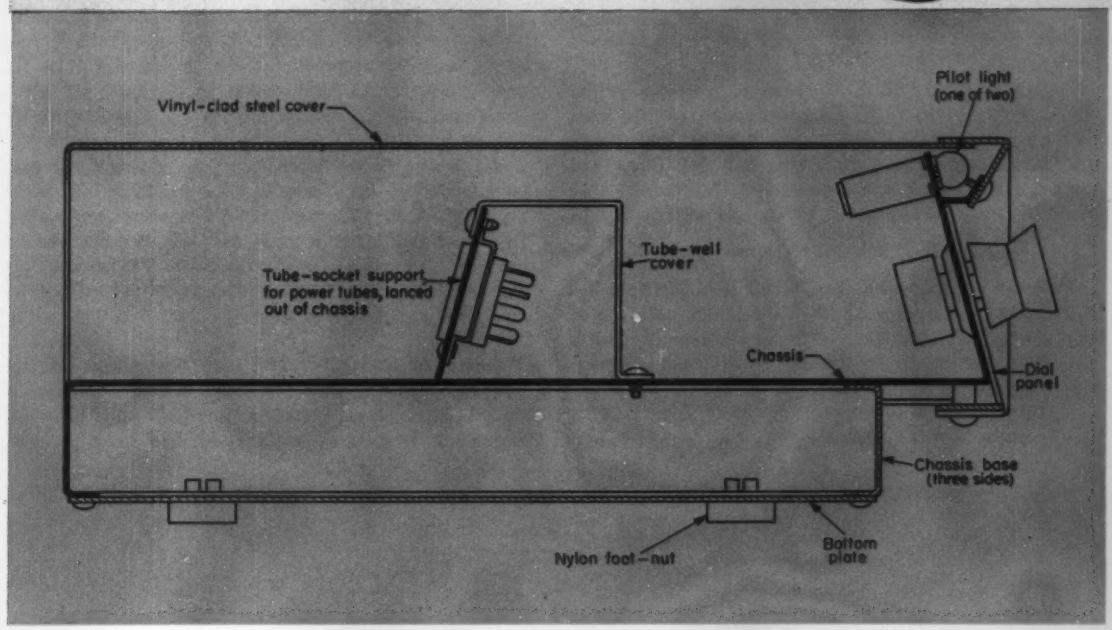


Designed with fully controlled amplitude, frequency and acceleration characteristics, vibrating screens made by the Meckum Engineering Inc. use Lignostone "springs" to support and guide screen case. Lignostone is a material developed in Germany and is composed of a compressed, long-fiber type wood. The wooden springs eliminate any weaving or dancing action of screen case.

Highly efficient stopping and reversing of screen-case motion is accomplished by several pairs of rubber buffer plates, which are mounted at right angles to each Lignostone spring. Drive power from motor is imparted by straight-line amplitude through a loose-coupled eccentric unit connecting the drive shaft to the screen case. The coupling is designed to prevent return of load or vibration to motor bearings.

Long, Low Cabinet Silhouette Achieved with Cantilever Chassis Design





By clever control-panel styling and chassis construction, the new Bell model 2325 high-fidelity amplifier gives the illusion of a unit only 3 in. high. Actually the cabinet is 4 in. thick. This long, low effect is produced by the long, high-contrast rectangular front-panel elements and an overhanging chassis arrangement.

Overall cabinet height requirements are minimized by mounting long power tubes in a nearly horizontal position. Tube socket support for power tubes is lanced out of chassis to an angle of 75 deg. Likewise the dial-panel support, which is integral with the chassis, is bent to a 75-deg angle.

Other design features include a push-pull on-off switch coupled to the loudness control, and a continuous strip of built-in diffused panel lighting.

How to select and use

Linear Ball Bushings

to obtain low-friction rolling-contact linear motion

BALL bushings have several advantages over plain sliding bearings. Friction is extremely low, binding and chatter is eliminated, and a high degree of precision (essentially zero clearance or play) can be attained. In addition, the substitution of rolling for sliding friction minimizes the need for lubrication and solves many of the lubrication problems usually associated with sliding bearings.

Ball bushings, Fig. 1, are presently available for shafts from ¼ to 4 in. diameter, with rolling load ratings from 13 to 4300 lb per bushing. As these size and load ranges indicate, ball bushings are used for applications ranging from instruments to machine tools, from small electronic equipment to processing machinery.

Mounting Arrangements: A ball bushing installation should be designed: (1) to prevent rotation of the shaft, and (2) to insure parallelism of shafts on which an assembly rides. Typical mounting arrangements are shown in Fig. 2.

If the mounted assembly must rotate as well as reciprocate, a rotary bearing must be used in combination with the ball bushing. One method, for example, is to use a needle bearing with the rollers riding directly on the outer housing of the ball bushing. Despite the built-in depressions in the ball bushing outer housing, the method has proved to be an acceptable solution.

One of the simplest methods of insuring shaft parallelism is to end-mount one shaft in blocks which can be dimensioned or shimmed up to the proper height. At final assembly, the bushing is run back and forth, and the blocks are doweled at the proper location.

When shafts are long, bending of the shaft may be a problem. In this case, an open type ball bushing, Fig. 3, can be used, and the shaft supported. In this bushing, one or more ball circuits are removed. The bearing is adjustable to provide no-clearance fits in the same fashion as the adjustable ball bushing discussed later.

Accuracy and Fits: The most important precaution in installing ball bushings is the avoidance of an interference fit between the shaft and the working bore (inside diameter) of the bearing. This

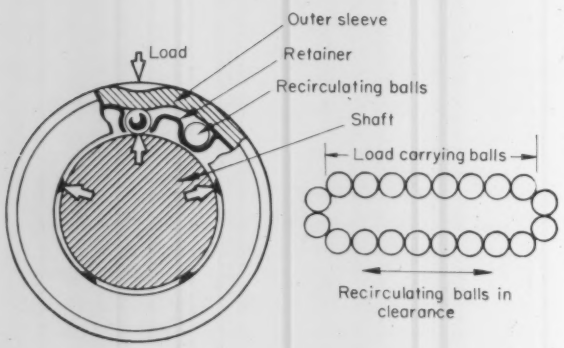


Fig. 1—Basic working parts of the Thomson ball bushing. Designed for linear motion only, the ball bushing contains three or more "loops" or complete circuits of balls. Balls in one portion of the circuit carry the load between the outer sleeve and the shaft. A retainer recirculates the balls to their starting points. The complete assembly has no loose parts, and the ball bushing can be removed as a unit from the shaft.

By HOWARD R. HAVEMEYER
Thomson Industries Inc.
Manhasset, L. I., N. Y.

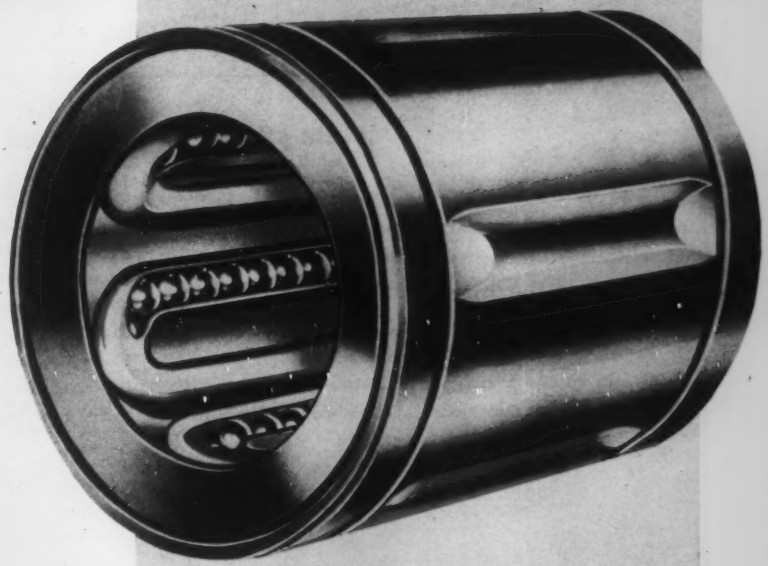
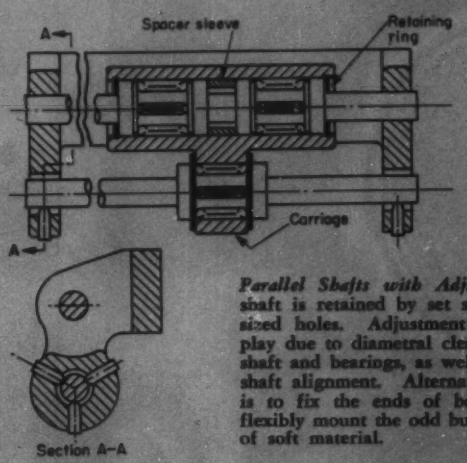
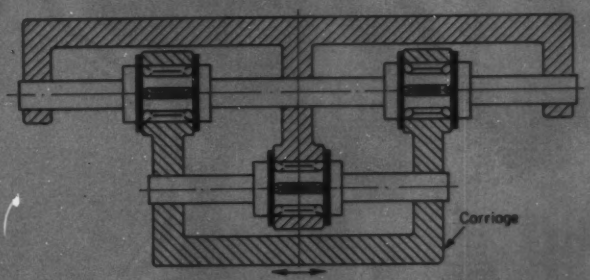


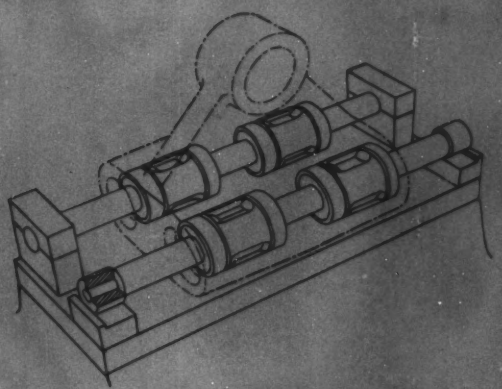
Fig. 2—Methods of mounting linear ball bushings.



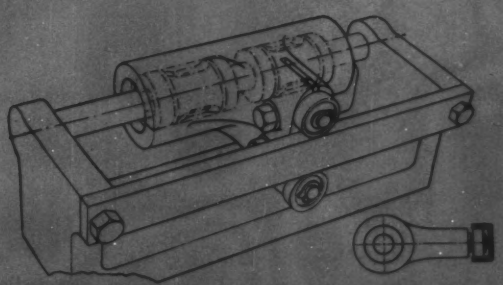
Parallel Shafts with Adjustment: One shaft is retained by set screws in oversized holes. Adjustment can take out play due to diametral clearance between shaft and bearings, as well as correcting shaft alignment. Alternate arrangement is to fix the ends of both shafts and flexibly mount the odd bushing in a ring of soft material.



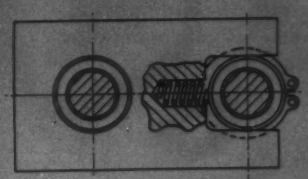
Long and Short Shafts: Two ball bushings on the carriage ride on a long fixed shaft; a third fixed bushing rides a parellel shaft mounted on the carriage.



Floating Shaft: Where load is in one direction, one shaft can float on rollers riding on hardened pads. Shafts are self-aligning in one plane, but pads must be dimensioned or shimmed to assure parallelism in the other plane.



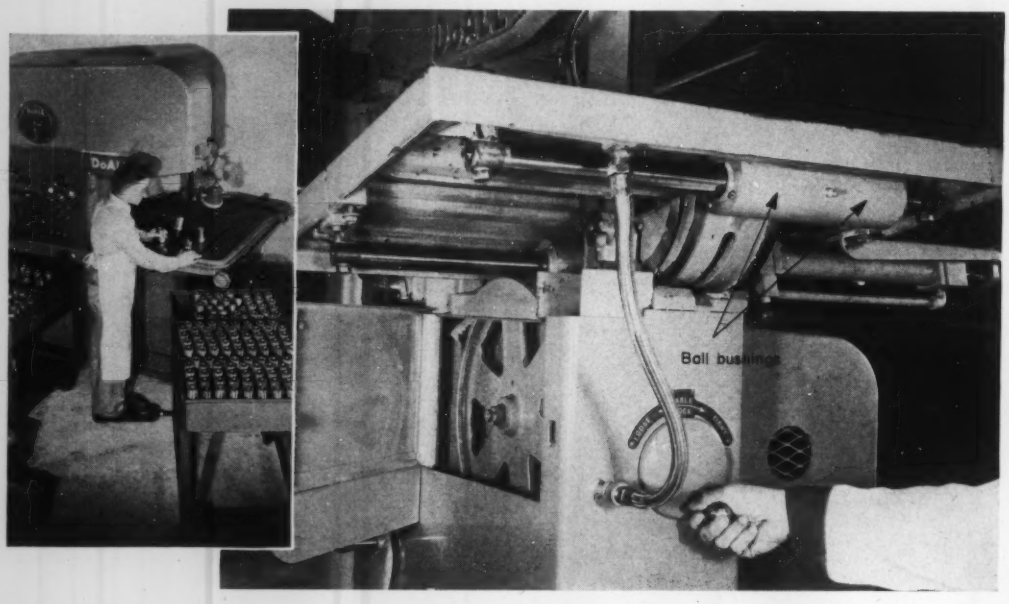
Single Shaft with Torque Rollers: Single or double rollers ride on a guide rail to prevent rotation. For relatively short strokes, linkages can also be used to prevent rotation.



Spring-Loaded Bushing: A floating ball bushing can be spring loaded to take out play. Spring force should be well in excess of maximum load on the bearing but no more than the rolling load rating of the ball bushing.

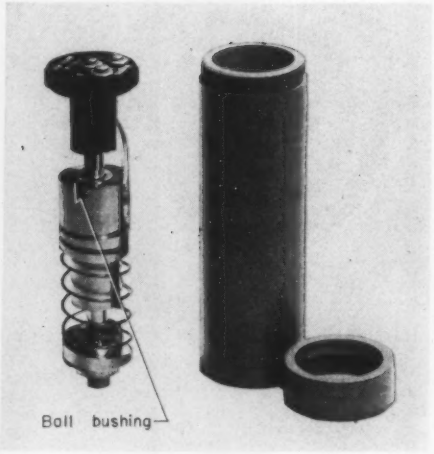
Tilting Work Table on Band Saw

Ball bushings are used on the DoALL model 26-3 Contourmatic band machine to provide flexibility of operation and easy movement of the hydraulically controlled work table. Four ball bushings on a tiltable trunnion mount provide support for the work table guide rods. The assembly method has several advantages: (1) low cost with adequate weight capacity for most sawing applications, (2) almost frictionless operation for power feeding or hand-controlled contour sawing, and (3) elimination of long ways. Note that considerable unbalanced overhang load occurs at maximum stroke, and that bearing loads vary considerably throughout the stroke—both conditions being satisfactorily met by wide-spacing the ball bushings.



Aircraft Accelerometer

Extremely low friction of a ¼-in. bore ball bushing is responsible for the sensitivity of the Bourns Laboratories 602A accelerometer. The instrument consists of an air-damped spring-mass system, with the mass mounted on a guide rod with the ball bushing. Measuring acceleration in aircraft and missiles, the instrument also requires minimum play in the bushing assembly.



can be caused by using a shaft having too large a diameter or by reducing the working bore by too tight a press or clamp fit. Misalignment will also produce the same effect.

Ball bushings may be retained in the housing hole by a press fit or a push fit in combination with several retaining means suggested in Fig. 4. If seals are used in the installation, a push-fit ball bushing can be retained by the press fit of the seal unit.

A press fit is perhaps the simplest way to retain a ball bushing, but care must be exercised to avoid too tight a press, as this could reduce the working bore of the bearing with resulting damage to the shaft or ball bushing. A light press should be used.

In clamp fit installations, such as suggested in Fig. 4, care must also be exercised to avoid excessive tightening of the clamp bolts. This too can reduce the working bore with possible damage to the bearing or shafts.

Two ball bushings are usually used in tandem unless the cocking loads are very light or shaft alignment is otherwise maintained. If a close-fit shaft is used or the bearings are expected to carry an appreciable load, the alignment of the two ball bushings is very important. To insure this, the mounting holes should be bored straight, after all other machine work on the housing is finished.

For conventional rotary ball bearings, perpendicularity of the mounting shoulder to the shaft axis is important to prevent cocking of the bearing. With ball bushings, by contrast, parallelism and concentricity of the mounting holes with the shaft axis are the critical factors. The mounting shoulder acts only as a stop.

In most installations where extreme precision is required, a line-to-line fit is desirable (indicated by the ability to rotate the shaft with light finger pressure). One method of obtaining precision is to push-fit the bearing into the housing, then selectively assemble the shaft with an interference fit of no more than 0.0001-in. per in. of bore diameter. The bushing must be gaged after assembly into the housing.

A second, and preferable, method of obtaining "no play" installations is to use an adjustable-diameter ball bushing, Fig. 5. This type of ball

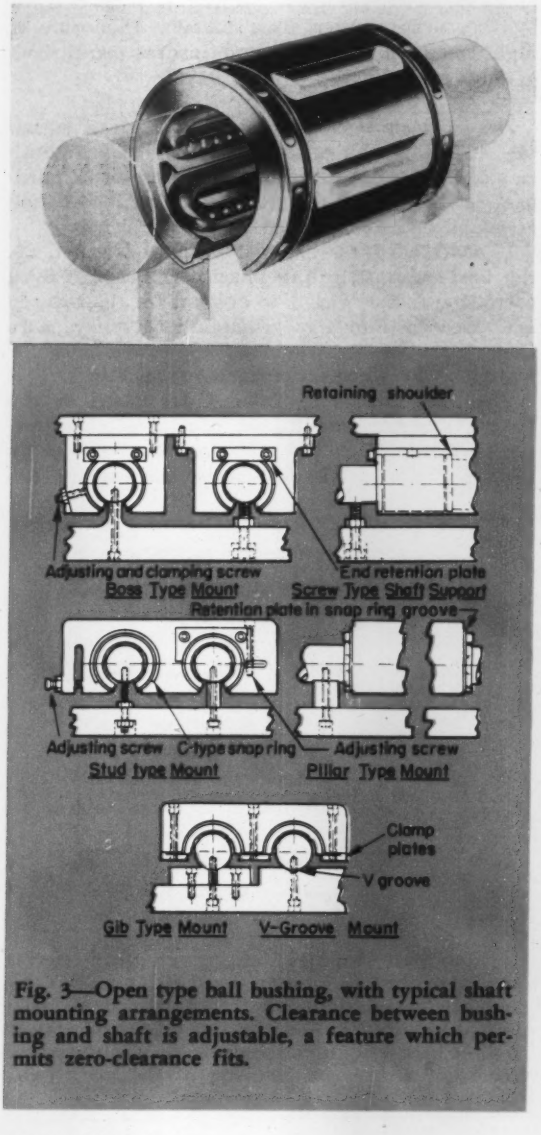


Fig. 3—Open type ball bushing, with typical shaft mounting arrangements. Clearance between bushing and shaft is adjustable, a feature which permits zero-clearance fits.

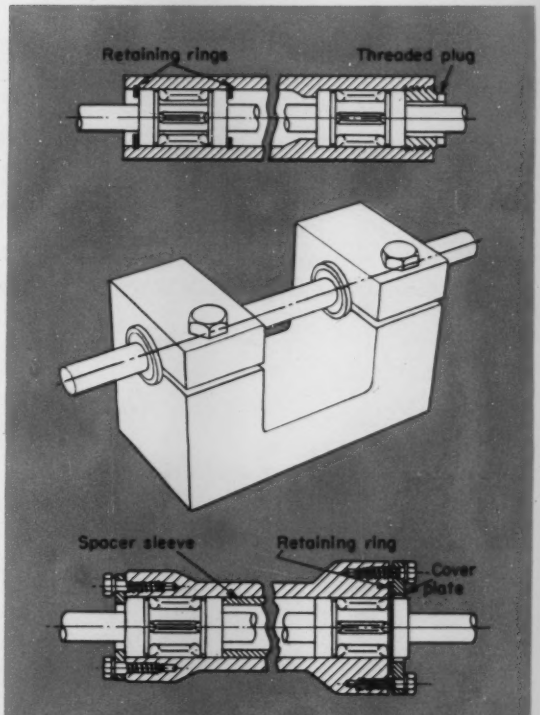


Fig. 4—Methods of installing standard ball bushings. With the clamp fit method, excessive tightening must be avoided.

Table 1—Dimensions and Load Ratings

Bore Diam (in.)	Ball Circuits (No.)	OD (in.)	Precision Series* Length (in.)	Precision Series* Rated Load Static (lb)	Precision Series* Rated Load Rolling (lb)	Precision Series* Bore Tol. (in.)	Commercial Grade Rated Load Static (lb)	Commercial Grade Rated Load Rolling (lb)	Commercial Grade Bore Tol. (in.)	Adj. Diam† Slot Width (in.)	Open Type† Ball Circuits (No.)	Open Type† Slot Width (in.)
0.2500	3	0.5000	0.750	22	13	−0.0005	19	11	+0.002	—	—	—
0.3750	4	0.6250	0.875	38	21	−0.0005	33	18	+0.002	—	—	—
0.5000	4	0.8750	1.250	72	46	−0.0005	61	39	+0.002	—	—	—
0.7500	5	1.2500	1.625	162	109	−0.0005	138	93	+0.002	3/32	4	1/16
1.0000	5	1.5625	2.250	262	202	−0.0005	222	172	+0.002	3/32	4	5/32
1.5000	6	2.375	3.000	695	535	−0.0006	—	—	——	1/8	5	1/16
2.0000	6	3.000	4.000	1100	850	−0.0008	—	—	——	1/8	5	7/32
2.5000	6	3.750	5.000	1710	1380	−0.0010	—	—	——	1/8	5	1 1/32
3.0000	6	4.500	6.000	2460	2000	−0.0012	—	—	——	1/4	5	1 5/16
4.0000	6	6.000	8.000	4760	4300	−0.0020	—	—	——	1/8	5	1 3/4

Static load ratings based on shaft hardness of Rockwell C 60. Rolling load ratings based on travel life of 2 million in.
*A high-precision series with closer tolerances on bore, and close concentricity tolerances, is also available.
†Load ratings same as precision series.

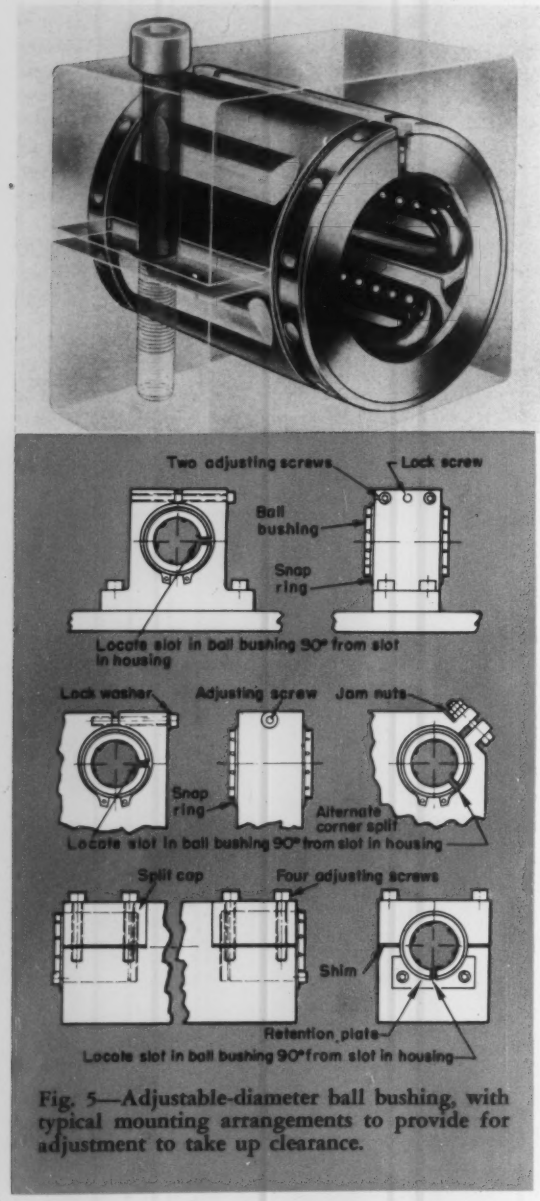


Fig. 5—Adjustable-diameter ball bushing, with typical mounting arrangements to provide for adjustment to take up clearance.

bushing can be adjusted to zero clearance after the shaft is in place.

For extreme location accuracy, the "high spot of eccentricity" of each bearing can be marked by the manufacturer. This permits alignment of high spots on assembly and insures parallelism of shaft centerlines.

Load Calculations: Static and rolling load capacities of ball bushings are given in Table 1. Both sets of figures are based on a minimum shaft hardness of Rockwell C 60, and the rolling load rating is established for a travel life of 2 million in.

If shaft hardness is lower than Rockwell C 60, the load capacity rating must be multiplied by a correction factor, Fig. 6, to account for the reduced load capacity. Similarly, to obtain a travel life more than 2 million in., the load capacities must be multiplied by a correction factor from Fig. 7.

The load ratings in Table 1 are based on the "worst" loading conditions. They are, therefore, conservative. When the load does not vary in direction of application, and when the bushing can

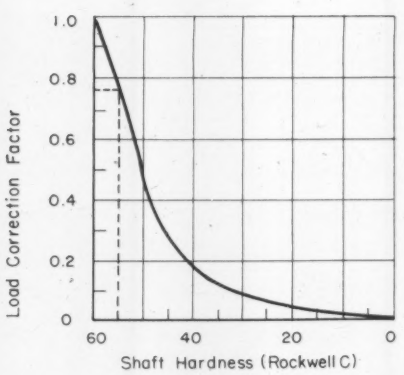


Fig. 6—Shaft hardness effects on load-carrying capacity of the ball bushing. Load rating from Table 1 must be multiplied by the correction factor shown. In practice, shaft hardness below Rockwell 55 C is used only under light load, when expected travel life is low, or grooving of the shaft (with resultant loose fit) can be tolerated.

be established in a fixed angular orientation with respect to the load, the load ratings can be increased. This requires, of course, that each bushing be installed and maintained in a definite angular position, Fig. 8. The load correction factors shown can then be used.

EXAMPLE: Three ball bushings are to be used to support a carriage on two parallel shafts. Carriage weight of 60 lb is equally distributed on the bushings. The carriage reciprocates on the shafts through a stroke of 2 in. at 300 cycles per minute. Design of the machine is based on an operating life of 3000 hr; shafts are hardened to Rockwell C 55 min.

Load capacity required per bushing is $60/3 = 20$ lb. Required travel life is $(2 \times 2)(300)(60)(3000) = 216$ million in. Dividing by the load correction factors from Figs. 6 and 7 gives $20/(0.21 \times 0.76) = 125$ lb, the required rolling load rating.

This application would require a bushing for a 1 in. diam shaft, Table 1. If however, the load is constant in direction, and each bushing can be installed so that the load is supported equally on two ball circuits, Fig. 8, a smaller bearing might do. Both the 1 in. and 0.75-in. bore bearings contain five ball circuits. Using the orientation load correction factor from Fig. 8 gives $125/1.463 = 85$ lb. Under these conditions, the 0.75-in. bore bushing would be satisfactory. If tolerances permit, a commercial grade bearing could also be used.

Ball bushing load-capacity ratings are based on the amount of travel which may be expected before shaft wear occurs. If provision can be made for rotation of the shaft to bring new bearing surfaces into play, a longer life will result. The shafts should be rotated with all load removed.

If soft shafts are used under moderate or high load conditions, the balls will form a groove along the working length. As a result, fit will be loose, but operation of the bearing will not be affected within reasonable depth limits.

For most moderate and high load applications

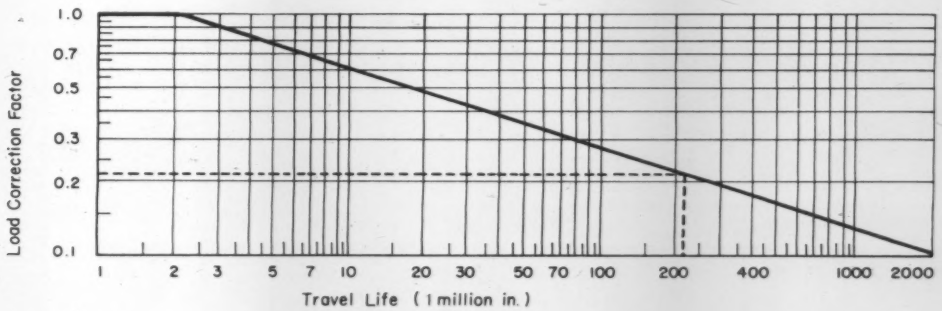
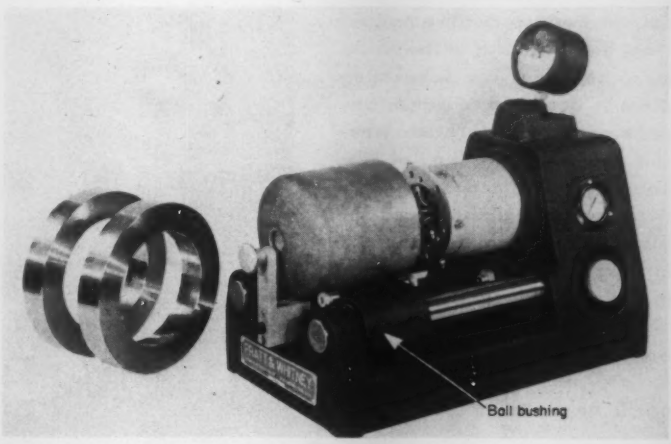


Fig. 7—Correction factor for travel life of bearing. Load ratings are based on a travel life of 2 million in. and must be multiplied by the correction factor if longer life is needed.

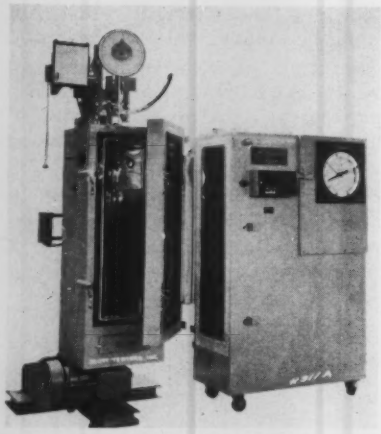
Gaging Instrument

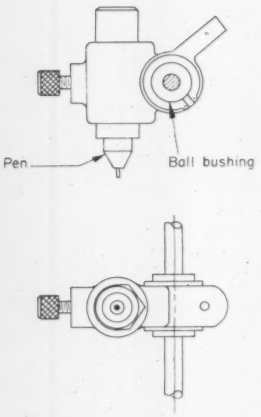
Special Air - O - Limit gage uses two ball bushings to support a slide. The Pratt & Whitney gaging fixture checks bores of refrigerator compressor housings for average diameter at several points along the length of the wall. The part is located from its OD on the slide, which also serves as a method of sliding the part on and off the gaging plug.

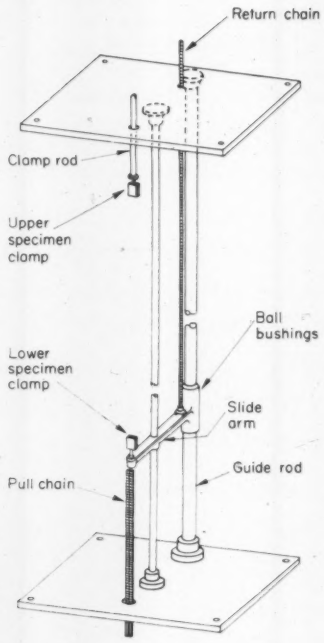


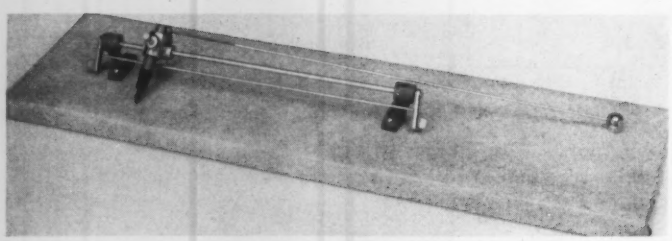
High and Low-Temperature Tester

Two ball bushings are used by Scott Testers Inc. on their model L-8 tester for rubber. Featuring a long stroke and quick return, the unit has a test chamber in which the sample is tensioned in air maintained at a control temperature between −70 F and 550 F by circulation through a separate conditioning unit. The ball bushings provide free motion of a slide arm carrying the lower specimen clamp. When a flat platen recorder is installed, a ball bushing is used in the pen carriage which carries either a fountain pen or sparking point to draw the stress-strain diagram.



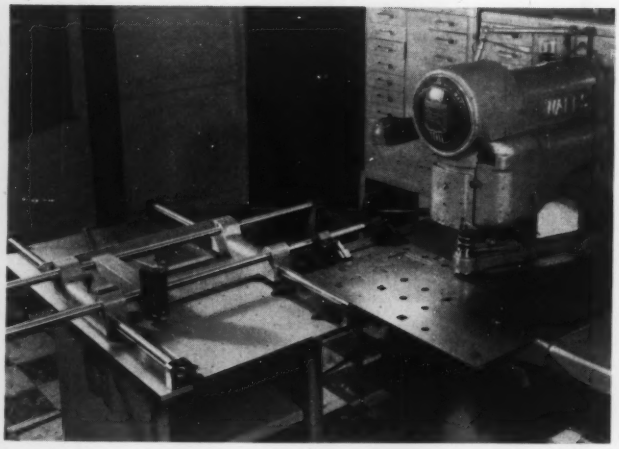






Duplicating Press

To provide minimum drag in locating a workpiece, the Wales-Strippit Positive Duplicator uses eight ball bushings in the workpiece carriage. The fabricating press is designed to punch any pattern of holes in printed-circuit boards. Location of the holes is determined by a stylus depressed into a hole in a template clamped to the Duplicator table. Workpiece is attached to the carriage and is moved along with the stylus. Accuracy between holes is held to 0.005-in. over the 15 by 25-in. capacity of the setup.



where maximum life is desired, shafts having hardnesses of Rockwell C 55 to 60 are normally recommended.

Coefficient of Friction: As might be expected for a linear ball bearing, coefficient of friction of ball bushings is quite low—ranging from 0.002 to 0.008.

From a practical standpoint, this low coefficient of friction is small enough to be ignored in most applications. Where minimum friction coefficient is critical, factors such as bushing size and loading, accuracy of mounting, cleanliness, and type of lubrication must be considered rather carefully.

Materials: In the precision series, balls are made of chrome steel, outer sleeve is 52100 bearing steel, retainers are C1020 steel, and end rings are B1113 steel. Stainless-steel versions of these bearings are available with Type 440 balls and sleeves, and 18-8 stainless retainers and end rings. The commercial grade bearing has C1010 steel balls, a C1020 sleeve and retainers, and B1113 end rings.

Seals and Lubricants: In most applications, seals or dust boots are not necessary, and may actually be undesirable if friction must be extremely low. However, for applications where an unusual amount of dust or dirt is present and must be excluded, the sealing arrangements shown in Fig. 9 have proved to be satisfactory. A press-fit seal can often be used on one or both ends to secure a push-fit ball bushing.

Since ball bushings operate on the principle of a rolling ball, they require much less lubrication than sleeve bearings. In some lightly loaded low-speed applications, ball bushings have been used without any lubrication whatsoever in atmospheres where corrosion is not a problem. For most applications, however, a lubricant is recommended to prevent rusting of the highly polished bearing surfaces and to minimize wear.

Oil is preferred for applications involving high speed and minimum friction. A light grease has the advantage of better surface adhesion and, therefore, affords longer bearing protection. The numerous pockets in the bearing retainer hold a liberal initial supply of grease.

Conventional oil or grease seals may be used to minimize loss of lubricant.

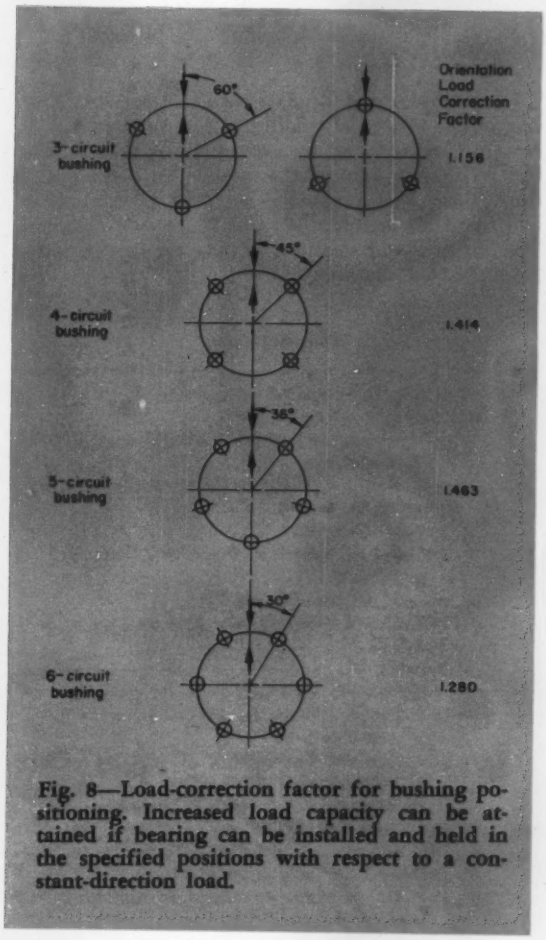
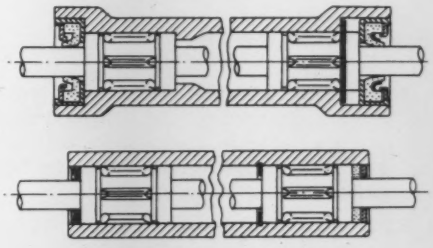


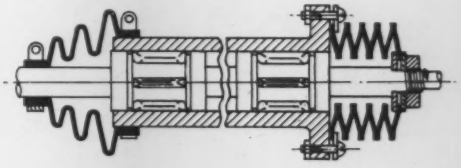
Fig. 8—Load-correction factor for bushing positioning. Increased load capacity can be attained if bearing can be installed and held in the specified positions with respect to a constant-direction load.

Fig. 9—Sealing methods.



Standard Seal: Synthetic-rubber seal with OD's to match standard ball bushings. Seals press-fit into hole bored to receive a push-fit ball bushing. Spring-loaded seals are used for shaft sizes 1½ in. or over.

Felt or Leather Washers: Retained by a press-fit ring, felt or leather washers protect against normal atmospheric dust and cause little friction. Washers are reasonable in cost, but will not hold lubricant over long periods of high-speed operation.



Dust Boots: Pleated or bellows type boots do not seriously affect linear friction. Molded synthetic type is shown at left, sewn cloth or leather at right. Cloth sock sewn over light wire coil spring is effective on long strokes. Venting of boot may be necessary if speeds are high.

Mechanics of Vehicles—7

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FORCES that act on a moving vehicle, reviewed in preceding articles of this series, are essential factors in performance and stability calculations. Certain static vehicle characteristics, fixed principally by the weight distribution of the vehicle (loaded and unloaded), are also significant to the vehicle designer. In this article, analytical and experimental methods for finding vehicle centers of gravity in the longitudinal, transverse and vertical directions are described.

How to Find the CG

The relationship between static axle reactions and cg position is revealed by consideration of Fig. 49. Axle reactions W_f and W_r are obtained by writing the moment-equilibrium equations for the ground-contact points:

$$W_f = \frac{W}{L}\left[L_r \cos\theta + H \sin(\pm\theta) \right] \qquad (91.1)$$

$$W_r = \frac{W}{L}\left[L_f \cos\theta - H \sin(\pm\theta) \right] \qquad (91.2)$$

$$W \cos\theta = W_f + W_r \qquad (91.3)$$

In these equations, it is assumed that the longitudinal and horizontal co-ordinates (L_r, L_f and H) of the center of gravity are known. The downhill axle carries the greater load because of the raised position of the cg. However, the sum of both axle reactions equals the normal weight component. Positive sign for angle θ is arbitrarily taken for an uphill slope.

Longitudinal and Transverse CG Location: Position of the center of gravity in the longitudinal direction can be found by weighing the vehicle, Fig. 50*a*. With one axle of the vehicle on a scale at a time, the other supported on firm ground, front and rear axle weights, W_f and W_r, can be obtained. The longitudinal position of the cg is calculated from the two relations

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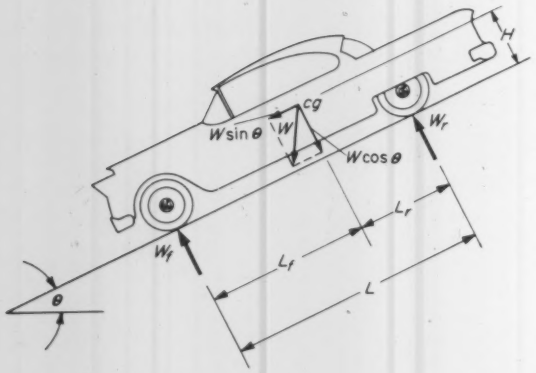

Fig. 49—Relationship between static axle reactions and position of the center of gravity. The downhill axle carries the greater load because of the raised cg.

Nomenclature

H = Height of center of gravity, ft
H_q = Height of cg of load, ft
I = Mass moment of inertia around cg of body, lb-ft-sec^2
J = Mass moment of inertia around oscillation point, lb-ft-sec^2
L = Wheelbase, ft
L_f = Distance between front axle and cg of vehicle, ft
L_q = Load action arm, ft
L_r = Distance between rear axle and cg of vehicle, ft
Q = Load, lb
r_f = Front-tire radius, ft
r_r = Rear-tire radius, ft
S = Wheel tread, ft
S_1, S_2 = Distances determining lateral cg position in relation to vehicle tread, ft
T = Oscillation time, sec
W = Vehicle weight, lb
W_f = Front-axle-weight (static), lb
W_r = Rear-axle weight (static), lb
W_1, W_2 = Static weight on the left and right-side wheels, lb

Center of Gravity

- **static axle reactions**
- **side-tilting**
- **weighing with elevated axle**
- **vehicle pendulum**

$$L_f = \frac{LW_r}{W}$$

$$L_r = \frac{LW_f}{W} \qquad (92)$$

Addition of co-ordinates L_f and L_r should give wheelbase L, affording a check on the accuracy of the measurements.

The transverse position of the center of gravity can be assumed to lie on the axis of symmetry of the vehicle only when vehicle weight is uniformly distributed on each side of the longitudinal axis. For accurate results, or on vehicles with asymmetrical weight distribution, the transverse position of the center of gravity can be determined by a method similar to that described. In this case, weights of the right and left-side wheels (W_1 and W_2) are found by weighing, Fig. 50*b*, and the co-ordinates of the transverse center of gravity location are determined from

$$S_1 = \frac{SW_2}{W}$$

$$S_2 = \frac{SW_1}{W} \qquad (93)$$

As a check, again $S_1 + S_2 = S$.

Height of CG: Determination of the vertical position of the center of gravity, distance H in Fig. 51, is more difficult. Following are the principal methods: (1) Side tilting, (2) Weighing with one axle elevated, and (3) The pendulum method.

SIDE TILTING: The vehicle is tilted sideways (Fig. 51) and the angle of inclination β is measured when the vehicle balances. By inspection of the geometry of the tilted vehicle,

$$H = r + \frac{S_1}{\tan \beta} \qquad (94)$$

This method presupposes a round tire cross section (point contact with the ground) and assumes an exact knowledge of S_1, the lateral position of the center of gravity. Accuracy of this method is highly questionable, since not all of these conditions are fulfilled in the usual case. Also, the necessary angular measurement may offer a problem. To create the best possible experimental conditions, high tire-inflation pressure should be used, and springs should be locked in position to prevent uneven deflection. Unavoidable tire distortion will, in any case, give uncontrollable errors. If higher than normal working tire pressure is used, correction for the effective tire radius should be made in the final result. This method of fixing cg loca-

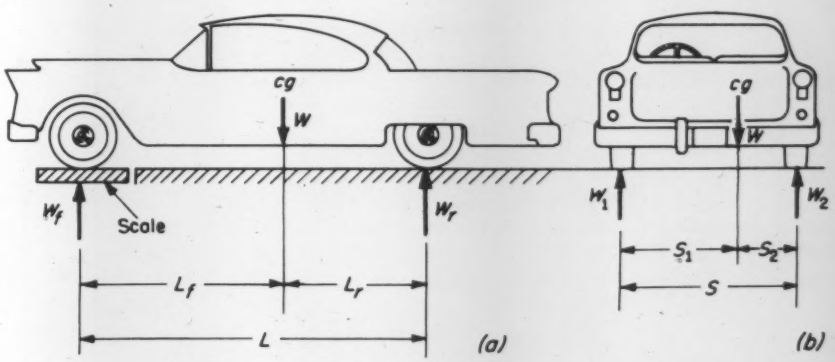

Fig. 50—Weighing front and rear axles one at a time, *a*, gives the longitudinal position of the cg. Where the cg is not on the longitudinal axis of symmetry, *b*, right-side and left-side wheels can be weighed to fix the transverse position of the cg.

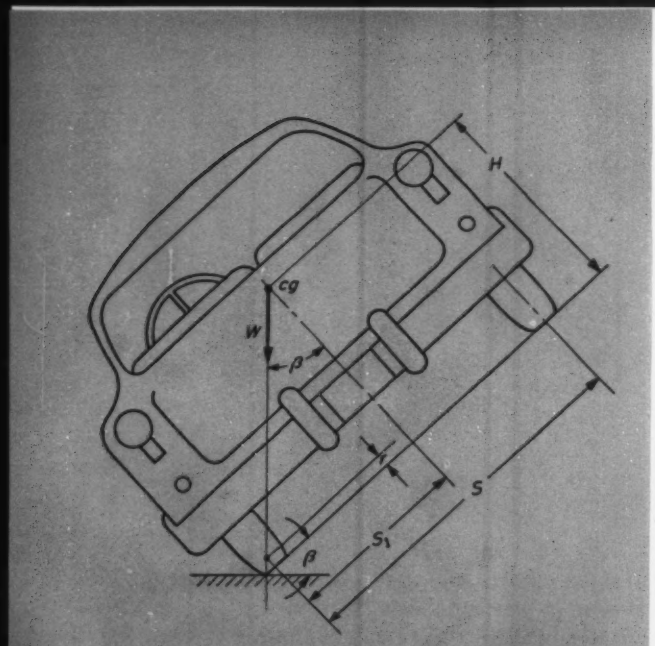

Fig. 51—By tilting the vehicle to one side until it balances, vertical height of the cg can be calculated from a measurement of tilt β. This method of locating the cg requires that front and rear wheels have the same tread.

tion is limited to vehicles with front and rear tires in line. Other wheel arrangements do not have the tilt axis parallel to the axis of symmetry of the vehicle, a condition which is necessary for use of the method.

WEIGHING WITH ONE AXLE ELEVATED: This method requires measurement of the weight of one axle; the other axle is raised to arbitrary height, n, Fig. 52. Actual height of the axle elevation is unimportant. The angle of tilt must be measured accurately, usually by determining one or both longitudinal distances L' and n. Springs should be locked in normal position, and the location of the center of gravity in the longitudinal direction (distance L_r) must be known. In elevating the axle, care should be taken that the hoist does not touch any part of the vehicle except the axle, since additional moments might be introduced that would disturb the results.

This method can be used irrespective of the wheel arrangement on the vehicle, for example, on three-wheel vehicles and with unequal tire diameters. Results can be obtained by the graphical or analytical methods described in the following.

Graphical Method: In many applications, a simple graphical method gives H quickly and with sufficient accuracy. Measuring the height of elevation n, and obtaining the corresponding weight of the lower axle, W_f' (Fig. 52), distance L_r' can be calculated from the expression

$$L_r' = \frac{W_t' L'}{W} = \frac{W_t'}{W} \sqrt{L^2 - N^2} \qquad (95)$$

where $N = n - r$.

This establishes a vertical line which crosses the known longitudinal position of the center of gravity and determines the cg position in the horizontal direction. Height H is next scaled from the layout, giving sufficient accuracy for the usual performance calculation.

Analytical Method: Evaluation of the vertical position of the cg for the difficult case of unequal front and rear tire diameters, Fig. 53, is illustrated by the following development.

Let the difference in loaded effective tire radii on rear and front axles be designated by Δr, where

$$\Delta r = r_r - r_f \qquad (96)$$

and r_f and r_r are radii of front and rear wheels. By inspection (Fig. 53),

$$L_r' = L_r \cos \beta + h \sin \beta$$

$$L' = x \cos \beta = (L - \Delta r \tan \beta) \cos \beta \qquad (97)$$

Dividing both equations by cos β and substituting L_r' and L' into Equation 95, it follows that

$$W_f' L - W_f' \Delta r \tan \beta = W L_r + W h \tan \beta \qquad (98)$$

For easier calculation, L_r can be eliminated by substituting

$$W L_r = W_f L \qquad (99)$$

from Equation 92. Height of the cg above the rear axle center is then

$$h = \frac{L(W_t' - W_f)}{W \tan \beta} - \frac{W_f \Delta r}{W} \qquad (100)$$

Angle β cannot be measured directly and will be

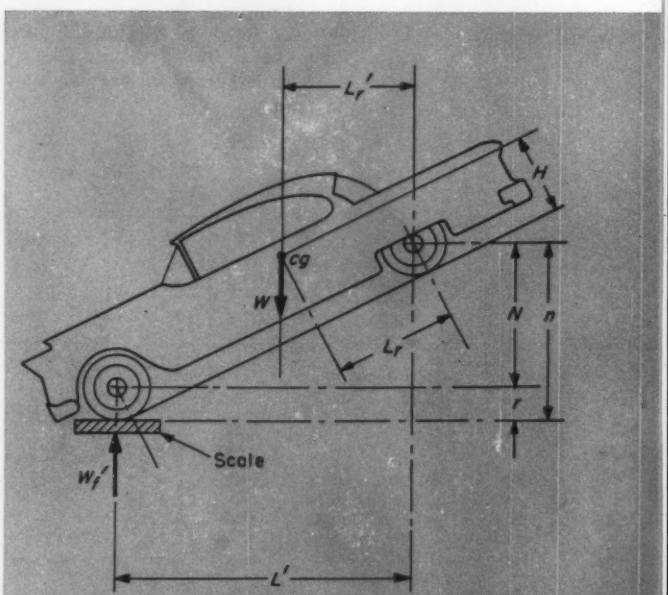

Fig. 52—Height of the cg can be determined by weighing one axle with the other elevated to arbitrary height n. With longitudinal cg position L_r known, L_r' is calculated from Equation 95. This allows two lines to be drawn that intersect at the vehicle cg. Height H can be scaled from the layout.

calculated from $\beta = \alpha - \gamma$, where the component angles are

$$\tan \alpha = \frac{N}{L'}$$

$$\tan \gamma = \frac{\Delta r}{L} \qquad (101)$$

Consequently,

$$\tan \beta = \tan (\alpha - \gamma) = \frac{\tan \alpha - \tan \gamma}{1 + \tan \alpha \tan \gamma}$$

$$= \frac{LN - \Delta r L'}{LL' + \Delta r N} \qquad (102)$$

Finally, for the cg height above the ground,

$$H = r_r + h = r_r + \frac{L(LL' + \Delta r N)}{(LN - \Delta r L')} \times$$

$$\frac{W_f' - W_f}{W} - \frac{\Delta r W_f'}{W} \qquad (103)$$

To limit length measurements in the elevated position to n only, L' can be eliminated by use of the relation

$$L' = \sqrt{L^2 - N^2 + (\Delta r)^2}$$

$$= \sqrt{L^2 - (n - r_f)^2 + (\Delta r)^2} \qquad (104)$$

Only the following measurements are then necessary: W_f = Weight of the front axle with vehicle on level ground, W_f' = Weight of the front axle with rear axle elevated, and n = Height of elevation of the rear-axle center.

For vehicles with equal tire radii on front and rear axles, Equation 103 is simplified, since $\Delta r = 0$ and $\gamma = 0$, giving

$$H = r_f + \frac{(W_f' - W_f) L \sqrt{L^2 - N^2}}{WN} \qquad (105)$$

Calculation of the height of the center of gravity by this method requires no special equipment, and accuracy is superior to the side-tilting method. It is recommended, however, that several calculations be made at different heights of rear-axle elevation and with front and rear axles alternately raised.

PENDULUM METHOD: This method of finding vertical cg position is based on the physical law that determines the oscillation period of a compound pendulum as a function of the center of gravity position of the swinging mass. The measuring arrangement consists of two pendulum structures of lengths h_g and h_s, carefully suspended on knife edges, Fig. 54. Location of the pendulum centers of gravity (unloaded) and their oscillation times are known. The vehicle is placed, successively, on both long and the short pendulums, and the oscillation times of the combined systems are measured. Height of the center of gravity is then calculated from oscillation times.

Described in detail in Reference 40, derivation of the expression for H, the vertical position of

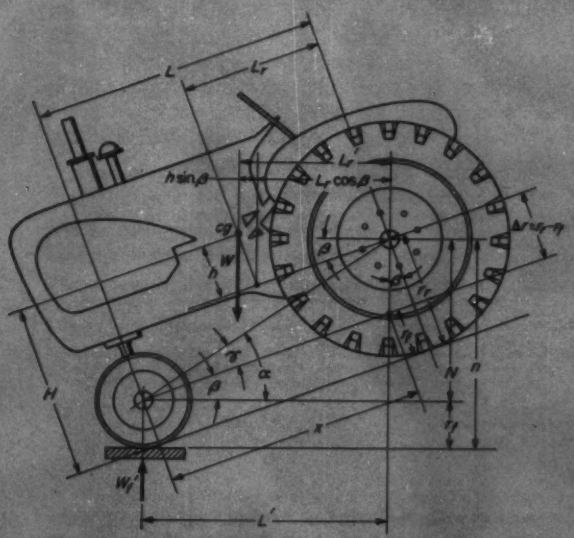

Fig. 53—When front and rear wheels have different diameters, height of the cg can be determined from Equations 100 and 103. Measurements required are: (1) Weight of front axle with the vehicle level, W_f; (2) Weight of front axle with rear axle elevated, W_f'; and (3) Height of rear axle, n.

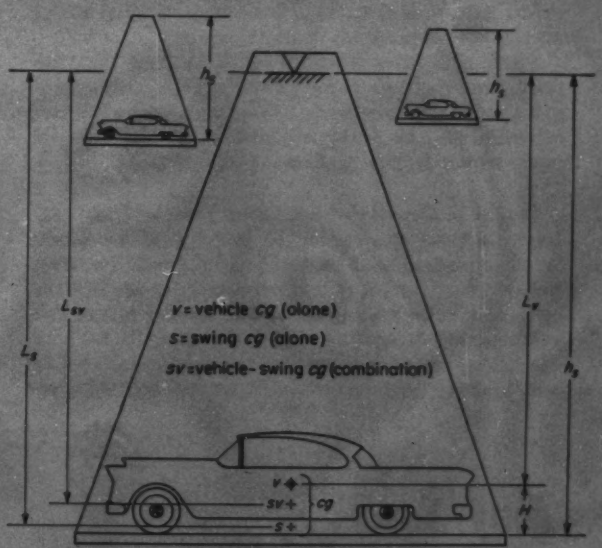

Fig. 54—Determination of center-of-gravity height by the pendulum method. Two "swing" structures (heights h_g and h_s) are used, and the oscillation time of each is measured with the vehicle on the platform. With all other pendulum data known, cg height can be calculated.

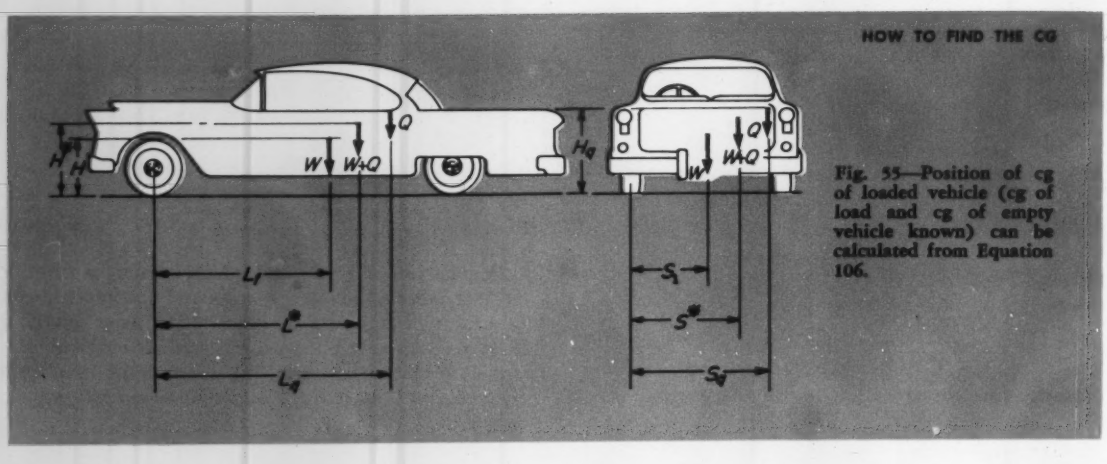

Fig. 55—Position of cg of loaded vehicle (cg of load and cg of empty vehicle known) can be calculated from Equation 106.

the vehicle cg, is not given here. Form of the equation, where cap and lower-case subscripts refer to the long and short swings, is

$$H = \frac{1}{W_v(T_{Sv}^2 - T_{sv}^2) - 8\pi^2 m_v(h_S - h_s)} \times$$
$$[W_s L_s(T_s^2 - T_{sv}^2) - W_S L_S(T_S^2 - T_{Sv}^2) +$$
$$W_v(T_{Sv}^2 h_S - T_{sv}^2 h_s) - 4\pi^2 m_v(h_S^2 - h_s^2)] \quad (106)$$

Containing, for the most part, known swing and vehicle constants, Equation 106 requires only the measurement of T_{sv} and T_{Sv}, which are the oscillation times of the short and long pendulums, respectively, with the vehicle in place.

For extreme accuracy in measurement, the buoyancy of the vehicle in the air and the increase of mass due to the entrapped air volume should be taken into consideration. Buoyancy of the swing structure is considered negligible.

From this brief description, it is seen that the pendulum method requires quite elaborate equipment and therefore finds use only in well equipped laboratories. Accuracy claimed is within ±1 per cent, which is the highest of all methods.

Center of Gravity of a Loaded Vehicle: For practical reasons, the center of gravity of a vehicle is often determined in the empty condition. Performance calculations, however, usually require the cg position to be known in the loaded state. For vehicles, which operate under changing loads, both conditions are of importance: the minimum traction and braking performance will be realized with vehicle empty, while other performance and stability calculations will use the loaded-vehicle data.

Center of gravity of the load can usually be calculated without difficulty. Designating the position of the center of gravity of any load Q_q as positioned on the vehicle with co-ordinates L_q, H_q and S_q, Fig. 55, the location of the loaded-vehicle cg can be calculated from

$$L^* = \frac{WL_f + \Sigma QL_q}{W + \Sigma Q}$$
$$H^* = \frac{WH + \Sigma QH_q}{W + \Sigma Q}$$
$$S^* = \frac{WS_1 + \Sigma QS_q}{W + \Sigma Q} \quad (107)$$

Starred values designate the cg co-ordinates of the loaded vehicle.

Knowledge of vehicle cg position leads to an evaluation of static and dynamic stability against tipping. Discussed in the next article of this series, the problem is particularly important on a vehicle that is designed to carry a load outside of its wheelbase. Fork lift trucks, front-end loaders, scoops and cranes are typical examples.

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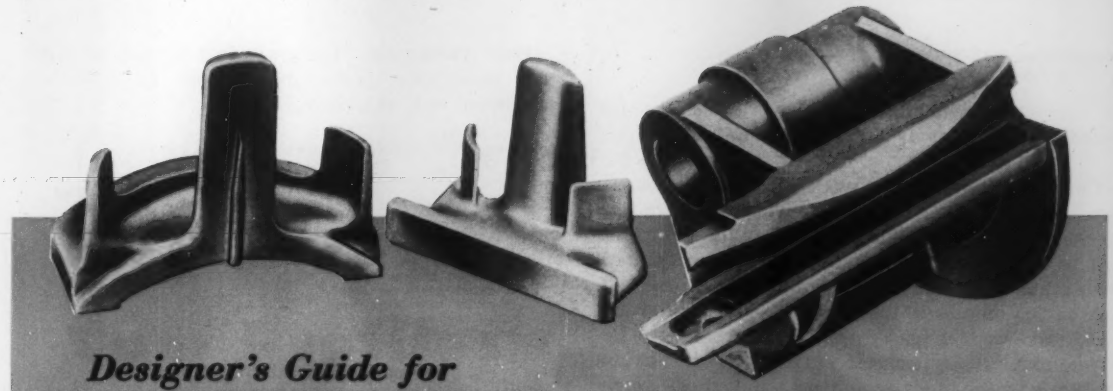
They Say . . .

"Perhaps, we will find part of our answer (to the shortage of technicians) through the increasing use of time-saving technical equipment such as the electronic computers we already are using in our organization on an ever-increasing scale . . . But I believe industry still does not have sufficient information collected on the formal training of technicians; who they are, how they could be trained better and in larger numbers. It might be advantageous for industry to join with appropriate local societies in broad studies which would serve to bring the problem into sharper focus."—JOHN L. YOUNG, *vice president engineering, United States Steel Co., Pittsburgh.*



Designer's Guide for

INVESTMENT CASTINGS

The dividing line between practical tolerances and precision that can be produced only at excessive cost is drawn by this article, based upon a chapter from *Investment Casting Engineering and Design Manual*, just published by the Investment Casting Institute.

PRINCIPAL advantages of investment castings are in producing parts requiring (1) close dimensional tolerances; (2) precise specification of surface finish; (3) intricate shapes and internal passages; and (4) high-temperature or difficult-to-machine alloys. Very precise parts can be produced. However, from the standpoint of economy, any design should be reviewed to determine if all specifications called for are actually necessary.

Surface Finish: As-cast surface finish depends largely upon the material. Values given are typical. The maximum allowable rms reading should be indicated and lower readings accepted.

Surface Finish

Material	As-Cast Finish microinches (rms)
Magnesium alloy	60—100
Aluminum alloy	60—100
AMS 4640 bronze	60—100
Beryllium copper	60—100
400-series stainless steel	100—125
300-series stainless steel	90—125
Cobalt-chrome alloy	80—100
Carbon steel	90—125

Dimensional Tolerances: Functional tolerances vary with part size and shape. For special requirements on small parts, closer tolerances can be held: ± 0.003-in. for dimensions to ¼-in. and ± 0.004-in. for dimensions ¼ to ½-in. However, such tolerances should not be used unless absolutely necessary due to high costs. Nonfunctional tolerances should be specified where possible.

Because of difficulty of inspecting small radii on a production basis, ± 1/64-in. min tolerance should be allowed. For larger radii use ±1/64-in. per 2 in. of radius. When vital, ±0.005-in. is held.

Dimensional Tolerances

Dimension (in.)	Tolerance (in.)
Functional	
Up to 1	±0.005
1 and over	±0.005 per in.
General	
Up to 2	± 1/64
2 to 4	± 1/32
4 to 6	± 3/64
Over 6	± 1/16

Straightness—Solid Bar

Length (in.)	As Cast (in.)	Corrected (in.)
Up to 2	±0.010	±0.005
2 to 4	±0.015	±0.010
4 to 6	±0.020	±0.010
Over 6	±0.030	±0.015

Flatness

Length (in.)	As Cast (in.)	Corrected (in.)
Up to 1	±0.008	±0.004
1 to 2	±0.016	±0.006
2 to 4	±0.030	±0.010
4 to 6	±0.045	±0.015

Straightness is a function of mechanical straightening and can vary to any degree desired. Tolerances given are practical production limits for a typical round shaft. Length is usually the determining factor for straightness, with diameter having little effect. Like straightness, flatness depends almost entirely upon part length, and can

be corrected mechanically. Tolerances are for "bow" only, not local surface irregularities.

Concentricity: When wall thickness is sufficiently thin to allow movement of material during mechanical straightening, tubular concentricity can be controlled mechanically. Small diameters with a heavy wall are almost impossible to correct. As the OD increases, the part becomes more workable, even with a heavy wall. Concentricity between external cylindrical surfaces is a function of straightness and roundness, and these tolerances should be used.

Tubular Concentricity

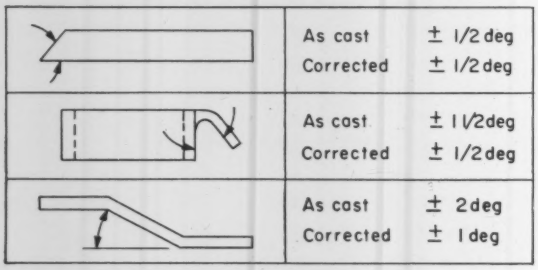
OD (in.)	ID (in.)	As Cast (in.)	Corrected (in.)
¾	¼	±0.004	±0.004
1	½	±0.005	±0.005
1½	¾	±0.008	±0.005
2	1	±0.010	±0.008

Roundness: For solid bars, as-cast roundness is affected by normal shrinkage variations within the metal. Corrections must be made by machining. For larger tubing, out-of-round can be corrected. Wall thickness is the controlling factor.

Roundness Tolerances

Diameter (in.)	SolidBar (in.)	Tube OD As Cast (in.)	Tube OD Corrected (in.)	Tube ID As Cast (in.)
Up to ¼				±0.006
¼ to ½	±0.005	±0.005	±0.005	±0.008
½ to 1	±0.008	±0.010	±0.006	±0.010
1 to 1½	±0.012	±0.012	±0.008	±0.015
1½ to 2	±0.015	±0.015	±0.010	±0.020

Angular Surfaces: Angular tolerances vary with nature of the part. For some parts, corrective operations can be made without machining or other nonfoundry operations. Long, narrow parts are subject to warpage and frequently require correction to achieve close tolerances.



Holes: Blind holes require cores that are supported at one end only. Through holes permit closer dimensional control and smaller-diameter holes. Core draft is not needed up to 1¼ in. diam; then 15 minutes of angle per side is used.

Minimum Hole Diameters

Length (in.)	Blind (in.)	Through (in.)
¼	⅛	⅛
½	¼	⅛
¾	½	3/16
1	⅝	1/4
1¼	¾	1/16
1½	¾	3/8
2	1	7/16
2½	1	1/2

Wall Thickness: Length, cross-section of part, and flowability factor of material all influence minimum wall thickness.

Minimum Wall Thickness
1½ by 1 in. Tube

Material	Min Wall (in.)
Magnesium alloy	0.050
Aluminum alloy	0.050
Beryllium copper	0.040
AMS 4640 bronze	0.060
400-series stainless steel	0.065
300-series stainless steel	0.050
Cobalt-chrome alloy	0.050
Carbon steel	0.060

Steel Tubing Minimum Wall

Length (in.)	ID (in.)	Wall (in.)
¼	⅛	0.030
½	¼	0.040
¾	⅜	0.050
1	½	0.060
1¼	¾	0.060
1½	1	0.060
2	1½	0.060
2½	1¾	0.060

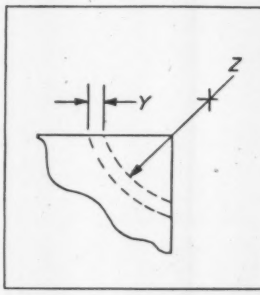
Hole Position: Tolerances for determining true positioning of holes, or bosses, varies with the reference diameter of the hole locations, when the holes are in a circle. For pairs of holes, the spacing tolerance depends on shape of part.

Position of Holes or Bosses

Reference Diameter (in.)	Tolerance (in.)
Up to 1	±0.005
1½	±0.009
2	±0.010
2½	±0.015
5	±0.025
8	±0.040
10	±0.050

Tapered or Angular Holes: For any hole up to 1½ in. deep, a tolerance of ±30 minutes is required. In deeper holes, a 45-minute tolerance is desirable. Tolerances for angular cored holes are affected more by length of hole than degree of angle. Holes up to 1-in. deep require ±30 minutes. Holes over 1-in. deep should be given 45 minutes.

Curved Passages: Size of opening and radius of curve for passageway take a different set of tolerances. Generally, rectangular holes require a larger tolerance span than do round holes. To determine proper tolerances for rectangular holes, the standard nonfunctional tolerance should be applied to the dimensions of the hole.



Y	Z	
1/4-in.	1/2-in.	±0.005
1/2	3/4	±0.005
3/4	1	±0.008
1	1 1/2	±0.010
1	2	±0.014
1	2 1/2	±0.016
1	3	±0.018

The complete manual can be purchased from the Investment Casting Institute, 27 E. Monroe St., Chicago 3, Ill.—$5.00 per copy.

Displacement Factors for Modified-Trapezoid Cam Profiles

By VIKTORAS BILAISIS
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AS THE speeds of machines increase, proper cam profiles with the best dynamic characteristics become more important. Parabolic cam profiles produce the lowest possible acceleration. In fast-moving cam systems, not only the acceleration, but also the rate of change of acceleration, or "jerk," is important. In this respect, parabolic cams have a poor characteristic—infinite jerk. At high speeds, the effect of this characteristic is the rapid deterioration of cam and cam-follower surfaces at acceleration changeover points. These points are at the start, the finish, and the middle of the rise or fall of dwell-rise-dwell applications.

On the other hand, cycloidal cam profiles have a low rate of acceleration change, but a 56.5 per cent higher peak acceleration and deceleration. Since force is directly proportional to acceleration ($F = ma$), this profile produces high forces on followers and linkages. As Neklutin* has pointed out, combining these two mathematical curves produces a good cam profile with respect to acceleration and jerk.

Since the modified trapezoid profile, Fig. 1, consists of more than one mathematical curve, it cannot be represented by a continuous function. Equations for motion change from point to point. They are indicated in Table 1.

*C. N. Neklutin—"Designing Cams," MACHINE DESIGN, Vol. 24, No. 6, June, 1952, Pages 143 to 160.

Nomenclature

a = Follower acceleration
H = Total rise of follower
n = Cam speed, rpm
v = Follower velocity
y = Follower displacement
β = Angular displacement of cam for total follower rise H
θ = Angular displacement of cam

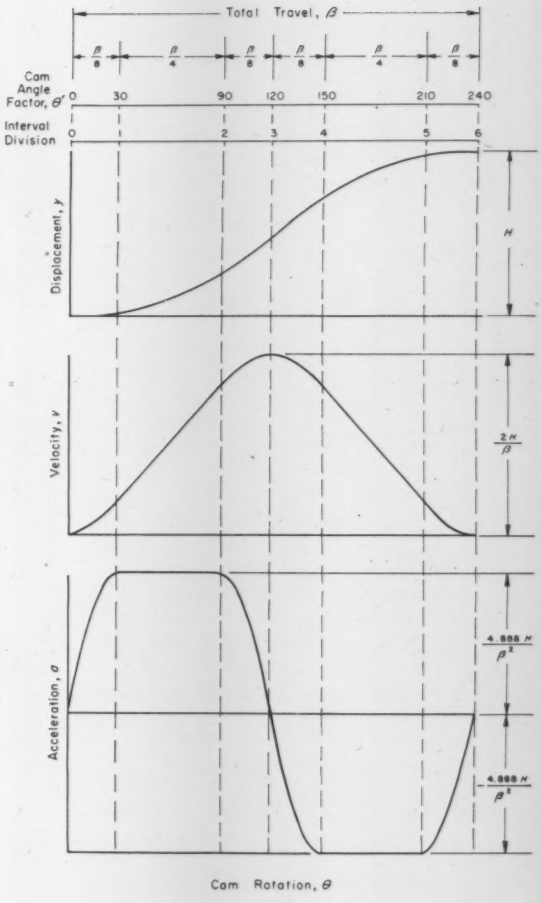


Fig. 1—Displacement, velocity, and acceleration plots for modified-trapezoid profile. Rotation and interval notations at top provide keys to equations of Table 1 and point values in Table 2.

Table 1—Modified-Trapezoid Cam Profile Equations

Interval (Fig. 1)	Displacement, y (in. or deg)	Velocity, v (in. per deg or deg per deg)*	Acceleration, a (in. per deg^2 or deg per deg^2)**
0 to 1	$0.09724612\left[4\frac{\theta}{\beta}-\frac{1}{\pi}\sin\left(4\pi\frac{\theta}{\beta}\right)\right]H$	$0.3889845\left[1-\cos\left(4\pi\frac{\theta}{\beta}\right)\right]\frac{H}{\beta}$	$4.888124\sin\left(4\pi\frac{\theta}{\beta}\right)\frac{H}{\beta^2}$
1 to 2	$\left[2.44406184\left(\frac{\theta}{\beta}\right)^2-0.22203097\frac{\theta}{\beta}+0.00723407\right]H$	$\left[4.888124\frac{\theta}{\beta}-0.222031\right]\frac{H}{\beta}$	$4.888124\frac{H}{\beta^2}$
2 to 3	$\left[1.6110154\frac{\theta}{\beta}-0.0309544\sin\left(4\pi\frac{\theta}{\beta}-\pi\right)-0.3055077\right]H$	$\left[1.6110154-0.3889845\cos\left(4\pi\frac{\theta}{\beta}-\pi\right)\right]\frac{H}{\beta}$	$4.888124\sin\left(4\pi\frac{\theta}{\beta}-\pi\right)\frac{H}{\beta^2}$
3 to 4	$\left[1.6110154\frac{\theta}{\beta}+0.0309544\sin\left(4\pi\frac{\theta}{\beta}-2\pi\right)-0.3055077\right]H$	$\left[1.6110154+0.3889845\cos\left(4\pi\frac{\theta}{\beta}-2\pi\right)\right]\frac{H}{\beta}$	$-4.888124\sin\left(4\pi\frac{\theta}{\beta}-2\pi\right)\frac{H}{\beta^2}$
4 to 5	$\left[4.6630917\frac{\theta}{\beta}-2.44406184\left(\frac{\theta}{\beta}\right)^2-1.2292648\right]H$	$\left[4.6660917-4.888124\frac{\theta}{\beta}\right]\frac{H}{\beta}$	$-4.888124\frac{H}{\beta^2}$
5 to 6	$\left[0.6110154+0.3889845\frac{\theta}{\beta}+0.0309544\sin\left(4\pi\frac{\theta}{\beta}-3\pi\right)\right]H$	$\left[0.3889845+0.3889845\cos\left(4\pi\frac{\theta}{\beta}-3\pi\right)\right]\frac{H}{\beta}$	$-4.888124\sin\left(4\pi\frac{\theta}{\beta}-3\pi\right)\frac{H}{\beta^2}$

* For constant-velocity rotation of cam, follower velocity can be obtained in in. per sec or deg per sec by multiplying these equations by $6n$ where n = cam speed, rpm.

** Follower acceleration can be obtained in in. per sec^2 or deg per sec^2 by multiplying these equations by $36n^2$.

Table 2—Displacement Factors for Modified-Trapezoid Profile

θ'	y'	θ'	y'	θ'	y'	θ'	y'
0[0]	0.000 000 00						
1	0.000 000 74	61	0.108 689 28	121	0.508 332 60	181	0.899 644 03
2	0.000 005 92	62	0.112 983 25	122	0.516 660 76	182	0.903 683 43
3	0.000 019 97	63	0.117 362 08	123	0.524 980 03	183	0.907 637 93
4	0.000 047 29	64	0.121 825 76	124	0.533 286 04	184	0.911 507 58
5	0.000 092 26	65	0.126 374 30	125	0.541 574 42	185	0.915 292 35
6	0.000 159 18	66	0.131 007 73	126	0.549 840 83	186	0.918 992 27
7	0.000 252 32	67	0.135 725 99	127	0.558 081 01	187	0.922 607 33
8	0.000 375 86	68	0.140 529 16	128	0.566 290 81	188	0.926 137 53
9	0.000 533 92	69	0.145 417 16	129	0.574 466 08	189	0.929 582 84
10	0.000 730 49	70	0.150 390 01	130	0.582 602 85	190	0.932 943 30
11	0.000 969 48	71	0.155 447 75	131	0.590 697 19	191	0.936 218 93
12	0.001 254 69	72	0.160 590 35	132	0.598 745 31	192	0.939 409 66
13	0.001 589 76	73	0.165 817 80	133	0.606 743 58	193	0.942 515 53
14	0.001 978 23	74	0.171 130 11	134	0.614 688 45	194	0.945 536 54
15	0.002 423 47	75	0.176 527 30	135	0.622 576 53	195	0.948 472 69
16	0.002 928 70	76	0.182 009 33	136	0.630 404 63	196	0.951 323 98
17	0.003 496 98	77	0.187 576 26	137	0.638 169 69	197	0.954 090 41
18	0.004 131 20	78	0.193 228 03	138	0.645 868 80	198	0.956 771 96
19	0.004 834 06	79	0.198 964 67	139	0.653 499 26	199	0.959 368 65
20	0.005 608 08	80	0.204 786 17	140	0.661 058 59	200	0.961 880 48
21	0.006 455 57	81	0.210 692 54	141	0.668 544 42	201	0.964 307 45
22	0.007 378 66	82	0.216 683 76	142	0.675 954 67	202	0.966 649 57
23	0.008 379 26	83	0.222 759 84	143	0.683 287 41	203	0.968 906 80
24	0.009 459 07	84	0.228 920 81	144	0.690 540 92	204	0.971 079 19
25	0.010 619 56	85	0.235 166 60	145	0.697 713 76	205	0.973 166 71
26	0.011 862 01	86	0.241 497 30	146	0.704 804 65	206	0.975 169 30
27	0.013 187 46	87	0.247 912 84	147	0.711 812 53	207	0.977 087 15
28	0.014 596 70	88	0.254 413 25	148	0.718 736 63	208	0.978 920 07
29	0.016 090 31	89	0.260 998 52	149	0.725 576 35	209	0.980 668 13
30[1]	0.017 668 66	90[2]	0.267 668 66	150[4]	0.732 331 34	210[5]	0.982 331 34
31	0.019 331 87	91	0.274 423 65	151	0.739 001 48	211	0.983 909 69
32	0.021 079 93	92	0.281 263 37	152	0.745 586 75	212	0.985 403 30
33	0.022 912 85	93	0.288 187 47	153	0.752 087 16	213	0.986 812 54
34	0.024 830 70	94	0.295 195 35	154	0.758 502 70	214	0.988 137 99
35	0.026 833 29	95	0.302 286 24	155	0.764 833 40	215	0.989 380 44
36	0.028 920 81	96	0.309 459 08	156	0.771 079 19	216	0.990 540 93
37	0.031 093 20	97	0.316 712 59	157	0.777 240 16	217	0.991 620 74
38	0.033 350 43	98	0.324 045 33	158	0.783 316 24	218	0.992 621 34
39	0.035 692 55	99	0.331 455 58	159	0.789 307 46	219	0.993 544 43
40	0.038 119 52	100	0.338 941 41	160	0.795 213 83	220	0.994 391 92
41	0.040 631 35	101	0.346 500 74	161	0.801 035 33	221	0.995 165 94
42	0.043 228 04	102	0.354 131 20	162	0.806 771 97	222	0.995 868 80
43	0.045 909 59	103	0.361 830 31	163	0.812 423 74	223	0.996 503 02
44	0.048 676 02	104	0.369 595 37	164	0.817 990 67	224	0.997 071 30
45	0.051 527 31	105	0.377 423 47	165	0.823 472 70	225	0.997 576 53
46	0.054 463 46	106	0.385 311 55	166	0.828 869 89	226	0.998 021 77
47	0.057 484 47	107	0.393 256 42	167	0.834 182 20	227	0.998 410 24
48	0.060 590 34	108	0.401 254 69	168	0.839 409 65	228	0.998 745 31
49	0.063 781 07	109	0.409 302 81	169	0.844 552 25	229	0.999 030 52
50	0.067 056 70	110	0.417 397 15	170	0.849 609 99	230	0.999 269 51
51	0.070 417 16	111	0.425 533 92	171	0.854 582 84	231	0.999 466 08
52	0.073 862 47	112	0.433 709 19	172	0.859 470 84	232	0.999 624 14
53	0.077 392 67	113	0.441 918 99	173	0.864 274 01	233	0.999 747 68
54	0.081 007 73	114	0.450 159 17	174	0.868 992 27	234	0.999 840 82
55	0.084 707 65	115	0.458 425 58	175	0.873 625 70	235	0.999 907 74
56	0.088 492 42	116	0.466 713 96	176	0.878 174 24	236	0.999 952 71
57	0.092 362 07	117	0.475 019 97	177	0.882 637 92	237	0.999 980 03
58	0.096 316 57	118	0.483 339 24	178	0.887 016 75	238	0.999 994 08
59	0.100 355 97	119	0.491 667 40	179	0.891 310 72	239	0.999 999 26
60	0.104 480 19	120[3]	0.500 000 00	180	0.895 519 81	240[6]	1.000 000 00

To simplify determination of the cam profile, point-by-point displacement factors are given in Table 2. These factors are dimensionless, with cam angle factor θ' going from 0 to 240 and displacement factor y' from 0 to 1. To determine increments on a cam and rise at these points, the given values of θ' must be multiplied by the ratio $\beta/240$ and the values of y' by H. For example, if β is 60 deg, the increment is $60/240 = 15$ minutes. If every other point is used, then increments would be $2(60)/240 = 30$ minutes. Every fourth point would be $4(60)/240 = 1$ deg.

Example 1: Assume that a cam is to be designed for the feed slide of a punch press. The feed is to occur in 120 deg, Fig. 2, travel is to be 4 in., and the machine is to operate at $n = 180$ rpm.

Table 3—Calculations for Example 1

Point No.	Angle, θ (deg)	Factor, y (Table 2)	Hy (in.)	$R+Hy$ (in.)
1	3	0.00015918	0.00063672	8.0006
2	6	0.00125469	0.00501876	8.0050
5	15	0.01766866	0.07067464	8.0707
15	45	0.26766866	1.07067464	9.0707
20	60	0.50000000	2.00000000	10.000
25	75	0.73233134	2.92932536	10.9293
35	105	0.98233134	3.92932536	11.9293
40	120	1.00000000	4.00000000	12.0000

Points 5 to 15 = region of maximum acceleration.
Point 20 = point of maximum velocity.
Points 25 to 35 = region of maximum deceleration.

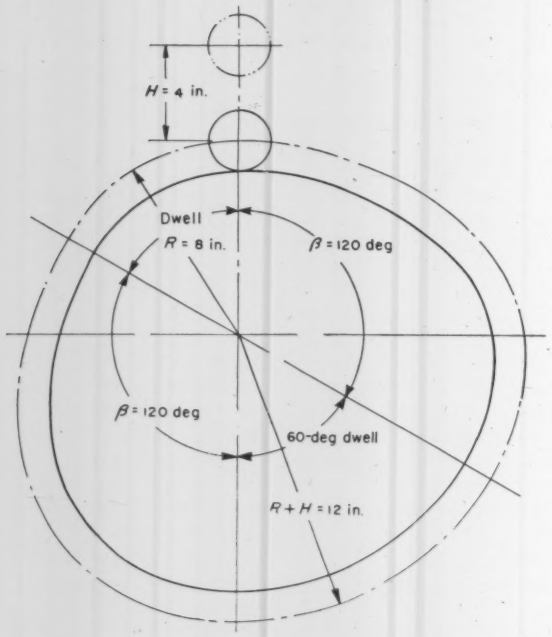


Fig. 2—Cam and follower layout for Example 2.

A modified trapezoid cam profile is selected, and every sixth point from Table 2 is used. Increments on the cam are $6(120)/240 = 3$ deg.

The calculations are shown in skeleton form in Table 3.

Maximum velocity occurs at the midpoint. From Table 1, Interval 2 to 3 (or 3 to 4),

$$v = \left[1.6110154 - 0.3889845 \cos \left(\frac{4\pi 60}{120} - \pi \right) \right] \frac{4(6)n}{120}$$

$$= (1.6110154 + 0.3889845) \frac{4(6)(180)}{120}$$

$$= 72.0 \text{ in. per sec}$$

Maximum acceleration is constant from 5 to 15. From Table 1, Interval 1 to 2,

$$a = 4.888124 \frac{4(36)(180)^2}{(120)^2}$$

$$= 1583.8 \text{ in. per sec}^2$$

Maximum deceleration is constant from 25 to 35 (Table 1, Interval 4 to 5) and equals -1583.8 in. per sec.^{2}

Example 2: A turret is indexed 30 deg by a modified trapezoid barrel cam in 150 deg of cam rotation. Find the maximum angular velocity and acceleration at the machine velocity of 180 indexes per minute. Or, $H = 30$ deg, $\beta = 150$ deg, and $n = 180$ rpm.

From Table 1, Interval 2 to 3,

$$v = \left[1.6110154 - 0.3889845 \cos \left(\frac{4\pi 75}{150} - \pi \right) \right] \frac{30(6)(180)}{150}$$

$$= 432 \text{ deg per sec}$$

From Table 1, Interval 1 to 2,

$$a = 4.888124 \frac{30(36)(180)^2}{(150)^2}$$

$$= 6335.0 \text{ deg per sec}^2$$

Similarly, other characteristics can be investigated by use of the equations in Table 1. Proper equations can be selected according to the interval notations in Fig. 1 and Table 1.

Cam Curves

In "Cam Curves and Cutter Pitch Curves," Pages 137-140, July 11 issue, errors occurred with respect to notation of vector terms. Beginning with Equation 3, all bold-face symbols should have been italic, indicating scalar quantities, with the exception of those contained in such terms as cos ($\mathbf{N}_1$, $\mathbf{R}_1$), sin ($\mathbf{T}_1$, $\mathbf{R}_1$).

Bearing characteristics of

Nickel-Base Alloys

By R. K. Kozlik
International Nickel Co.
Bayonne, N. J.

MATING of a variety of nickel-base alloys with dissimilar alloys containing hard phases, or soft phases with good lubricating qualities, effects substantial improvements in wear-resistant characteristics.

Hardnesses and approximate compositions of alloys under discussion are shown in Table 1. Discussion is based on results of tests to determine wear and galling characteristics of these alloys.

Wrought Alloys: Three basic nickel alloys, A Nickel, Monel and Inconel, gall readily when self-mated. The low resistance of these alloys to galling is one reason why they are not usually mated with themselves unless bearing pressures are low and lubrication adequate. Similar tendency to ready galling has been observed for many austenitic types of stainless steel.

Where more resistance to wear and galling is required of these high-nickel alloys, their age-hardenable wrought counterparts, Duranickel, K Monel, and Inconel X, may be applied with better success. Even with these, there are limitations on maximum permissible bearing stress. There is no strict hardness-wear resistance relationship for high-nickel alloys.

Cast Alloys: It has been possible, through alloying, to develop cast versions of the three major nickel-base alloy types with great resistance to wear and galling. Cast G Nickel and S Nickel are essentially nickel alloyed with carbon and silicon respectively. Cast H Monel, S Monel and S Inconel also owe their improved wearing properties to silicon.

G Nickel mated with itself shows benefits derived from graphitic carbon when lubricated. This alloy is found to be useful without lubrication if bearing pressures are no higher than 2000 to 3000 psi.

Addition of 5.5 to 6.5 per cent

Table 1—Hardness and Approximate Composition of Wrought Alloys

Alloy	Composition (per cent) Ni	Cu	Cr	Fe	Si	Mn	C	Other	Brinell Hardness
A Nickel	99.6	...	...	0.05	0.02	0.25	0.07	.....	196—Cold drawn
Duranickel	93.8	...	...	0.12	0.58	0.38	0.20	4.5 Al, 0.4 Ti	235—Cold drawn
Monel	66.0	31.2	...	1.41	0.14	1.05	0.19	.....	235—Cold drawn
K Monel	65.5	29.1	...	0.96	0.12	0.60	0.15	3.0 Al, 0.5 Ti	340—Aged
Inconel	78.5	...	14.5	6.40	0.20	0.23	0.07	.....	262—Cold drawn
Inconel X	72.9	...	15.0	6.77	0.42	0.59	0.04	0.9 Al, 2.4 Ti, 1.0 Nb	340—Aged
17-7 PH Stainless	6.7	...	17.2	Bal.	0.36	0.64	0.07	1.0 Al, 0.02 P	436—Hardened
304 Stainless	9.1	...	18.3	Bal.	0.67	0.65	0.07	.....	180—Annealed
G Nickel	94.2	...	...	0.5	1.5	0.80	1.5	.....	131
S Nickel	90.0	...	...	2.0	6.0	0.78	0.68	.....	241
H Monel	63.0	30.5	...	1.5	3.2	0.80	0.10	.....	215
S Monel	63.0	29.5	...	2.0	4.0	0.80	0.08	.....	364
Inconel	71.5	...	16.0	8.0	2.0	1.0	0.20	.....	166
S Inconel	70.8	...	15 2	7.0	5.4	1.3	0.21	.....	277
Colmonoy 6	65-75	...	13-25	...	†	...	†	2.7–4.7 B	...
Waukesha 23	78	...	...	...	...	2.0	...	8 Sn, 4 Pb, 8 Zn	179
Waukesha 50	60	...	12.5	14.0	0.75	0.75	...	6 Sn, 3 Mo, 3 Bi	161
Waukesha 88	Bal.	...	12.0	...	0.20	0.80	...	4 Sn, 3 Mo, 3.5 Bi	127
Leaded Bronze	0.46	79.9	...	...	...	...	...	6.3 Sn, 10.1 Pb, 2.1 Zn	69
Neveroil 21*	32.3	64.5	...	†	...	...	†	Sn present	17

*Pressed and sintered product. †Present

silicon to cast nickel results in formation of free silicides which eliminate wear and galling at bearing pressures as high as 33,500 psi when lubricated. There is no tendency for S Nickel to gall at higher bearing pressures even though some wear occurs.

Two cast nickel-copper alloys, H Monel and S Monel, also owe their improved wearing qualities to hard silicides. The nominal 3.2 per cent silicon added to H Monel has resulted in an alloy designed for applications requiring good corrosion resistance, high strength, moderate ductility and a higher level of gall or wear resistance than regular cast Monel. The S Monel containing nominally 4 per cent silicon, is even stronger and more wear resistant, but has a lower level of ductility.

Cast Inconel, a nickel-chromium-iron alloy, may be used to resist oxidation at elevated temperatures and is particularly satisfactory in corrosive media that include oxidizing acids and oxidizing acid salts, where Monel is of limited value. It is also good in applications where bearing pressures are low. Silicon and carbon additions are required if service conditions, with respect to wear, are more severe. Addition of as little as 3.5 per cent silicon results in marked improvement, and better results are obtained with 5.5 per cent silicon. Wear test results show S Inconel, containing 5.5 per cent silicon, to be capable of operating at stresses as high as 50,000 psi without difficulty. At higher stresses, test surfaces remain smooth and shiny even though wearing is more rapid. Relative insensitivity of the frictional coefficient to bearing pressure, shown by this alloy, is a further indication of stability of wearing surfaces after inception of wear.

Several corrosion-resistant hard-surfacing alloys are commercially available. One of these is Colmonoy 6. Presence of borides, carbides and silicides in the nickel-chromium-iron matrix apparently is responsible for the very low wear rate observed at all bearing pressures surveyed. This alloy, and other similar hard surfacing alloys, is expected to be quite suitable for meeting severe service requirements when surfacing methods are applied.

Dissimilar Alloy Combinations: Most wrought nickel alloys do not have outstanding antiwear properties if mated with themselves. Duranickel, mated with either S Nickel or G Nickel, performs well. If bearing stresses below 18,500 psi are encountered, G Nickel is preferable because of superior machinability. At higher stresses, or where lubrication may be intermittent or absent, S Nickel is preferable. It is probable that neither alloy could be mated with A Nickel satisfactorily.

A good alloy mate for Inconel X is S Inconel. Its performance with wrought Inconel is such as to indicate improvement over self-mated Inconel, but service requirements would necessarily need to be moderate with bearing stresses lower than 20,000 psi and with lubrication provided. Galling is so severe when S Inconel and 17-7 PH stainless steel are mated, that it is doubtful that such a combination could be successful except under the mildest of operating conditions.

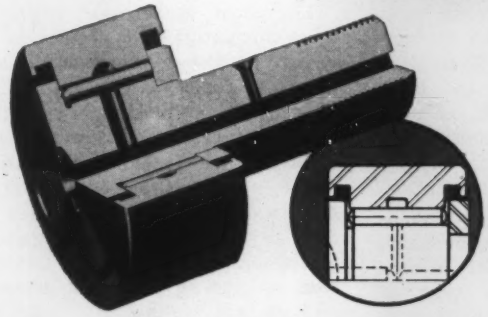
Table 2—Guide to Expected Performance of Lubricated Nickel Alloy Combinations*

	A Nickel	Duranickel	Monel	K Monel	Inconel	Inconel X	17-7 PH	304 Stainless	G Nickel	S Nickel	H Monel	S Monel	Cast Inconel	S Inconel	Colmonoy 6	Waukesha 23	Waukesha 50	Waukesha 88	Leaded Bronze	Neveroil 21	Hard Cr Plate	Molybdenum Disulfide Coat	Sulfurization Coat
A Nickel	P																						
Duranickel	P	F																					
Monel	P	P	P																				
K Monel	P	F	P	F																			
Inconel	P	P	P	P	P																		
Inconel X	P	F	P	F	P	F																	
17-7 PH	P	P	P	P	P	P	P																
304 Stainless	P	P	P	P	P	P	P	P															
G Nickel	P	G	F	F	F	F	P	P	G														
S Nickel	P	G	F	F	F	G	P	P	F	G													
H Monel	P	F	F	F	P	F	P	P	F	F	F												
S Monel	P	G	F	F	F	G	P	P	F	G	F	G											
Cast Inconel	P	P	P	P	P	P	P	P	F	F	P	F	F										
S Inconel	P	G	F	F	F	G	P	P	F	G	F	G	F	G									
Colmonoy 6	P	G	F	F	F	G	P	P	F	G	F	G	F	G	G								
Waukesha 23	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G							
Waukesha 50	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G						
Waukesha 88	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G					
Leaded Bronze	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G				
Neveroil 21	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G			
Hard Cr Plate	P	P	F	F	P	P	P	P	F	P	P	P	P	P	P	G	G	G	G	G	P		
Molybdenum Disulfide Coat	F	F	F	F	F	F	F	F	F	P	P	P	F	P	P	G	G	G	G	G	F	G	
Sulfurization Coat	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G

*G=Good, F=Fair, P=Poor.

BEARING TIPS by McGill

sealed CAMROL® bearings lock out contamination in critical cam follower applications



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The new SCF series of the famous CAMROL cam follower completely seals out dirt, chips, moisture, etc. — an important advantage where the life of an ordinarily open mounted cam follower can be materially increased with adequate protection against contamination. Also the sealed bearing is pre-lubricated with provision made for easy re-lubrication, if desired, through either end of the stud.

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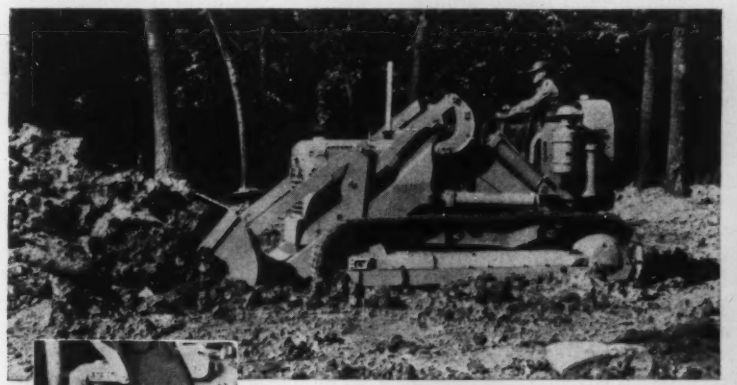
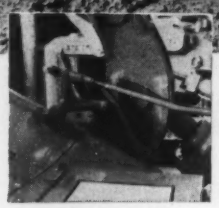
These same advantages are available in the SCYR sealed series Cam Yoke Roller (without stud). Specify CAMROL bearings with the built-in seals that preserve cam follower dependability in critical cam action, support or track roller application.





Built-in seals protect and preserve CAMROL® bearings from contamination in CATERPILLAR tractor-shovels

McGill SCF series sealed CAMROL bearings provide the cam action that positions the bucket of the 977 Traxcavator unit at the selected digging angle. Mounted on bell crank arms that are actuated by contact with a cam shoe on a hydraulic cylinder, these bearings are operating in the open and exposed constantly to dust, dirt and moisture. External surfaces have a black ferrous-oxide finish to prevent corrosion. These sealed McGill cam followers eliminate the need for relubrication and maintenance after installation. Caterpillar uses other McGill bearings including twelve CYR series cam yoke roller bearings in the flywheel clutch.

378 sealed CAMROL® bearings guide engine blocks in INGERSOLL automatic milling machine

The sealed CAMROL bearings used in this machine, guide cylinder blocks during transfer through various milling, boring and drilling operations. The bearings, used in place of guide bars, eliminate surface scratching of the 200 to 300 pound blocks which are transferred at speeds up to 400 feet per minute. Blocks are processed at the rate of 95 per hour. Ingersoll reports freer movement, accuracy of positioning and materially longer bearing life due to the new design that seals metal chips out of the bearings.

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Precision Needle Bearings

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The combination of cast S Monel with wrought K Monel results in a lower wear rate than for K Monel mated with itself. Best results can be expected at bearing pressures of about 20,000 psi or lower, with lubrication.

Results of testing have permitted establishment of Table 2 showing expected performances of various alloy combinations when lubricated with a light turbine oil.

Alloys whose resistance to wear depends on presence of hard particles in the structure may not always be used with good results when in contact with alloys of poorer wear resistance. Hardness is no criterion of expected behavior since 17-7 PH stainless, with a hardness of 436 bhn, consistently galls more readily and wears more rapidly than either wrought Inconel, 262 bhn, or Inconel X, 340 bhn, in contact with S Inconel. Alloys such as A Nickel, Monel or stainless steel derive little benefit from being mated with alloys containing hard microconstituents. However, the age-hardenable high-nickel alloys show improvement.

Bearing Alloys: Most bearing alloys consist of a matrix of some type containing phases rich in lead, tin or bismuth which promote formation of low-shear-strength, high-ductility films on contact surfaces, and which minimize galling tendencies. When running at successively higher bearing loads, rapid deterioration of these alloys may be expected at pressures above their compressive yield strengths. This factor of low compressive yield strength must also be recognized before serious consideration can be given to the type of bearing alloy that should be selected for any application.

Several wrought nickel alloys were tested against a leaded copper-tin bearing bronze. When lubricated, both the bronze and nickel alloy mate showed no tendency to gall or wear. Even with bearing pressure above the compressive yield strength of the bronze, most wear was confined to the bronze which wore rapidly at 17,500 psi without lubrication.

Often it is impossible to maintain adequate lubrication, in which case oilless bearings must be considered. Although this type of bearing alloy must be limited to low pressures, performance is good regardless of whether it is presoaked in oil only, or has been lightly oiled on wearing surfaces before use.

Occasionally, bearing alloys are required that have better corrosion resistance than leaded bronze. The Waukesha alloys, 23, 50 and 88 fall into this category. Strength properties are substantially higher than those of the leaded bronzes.

It is possible to reduce the wear rate of A Nickel to a very low value and eliminate galling by mating with Waukesha 23 or 50 alloys, when lubricated. The Waukesha 88 alloy has recently superseded the 50 alloy because of its superiority when mated with various types of austenitic stainless steel.

Protective Coatings: Success of 0.001-in. thick hard chromium electro-deposits in protecting Monel from galling and wear depends in large on the mating combination. The coating successfully raises the bearing stress required to initiate galling when uncoated Monel is mated with coated Monel. Molybdenum disulfide coatings are also useful within limits, particularly when self-mated.

The most spectacular improvement in antigalling properties is shown by alloys which have been given a fused salt sulfurization treatment. Untreated Type 304 stainless steel is found to gall excessively at 14,000 psi bearing stress, while treated stainless steel operates self-mated at stresses as high as 61,000 psi without galling when lubricated. Without lubrication, no galling occurs at stresses as high as 22,000 psi.

Success or failure of surface coatings for wear and galling resistance depends on the nature of both coating and application. The coating must overcome any galling tendencies of the basis alloy and must be adherent enough to remain on the metal surface during use. In addition, benefits of the coating may be expected only as long as it remains intact. This means that coatings are generally of limited use for moving parts unless they are resistant to wear or can be replaced as they wear away. Unless very thin coatings can be used, it may be necessary to make dimensional allowances.

From a paper entitled "Wear and Frictional Characteristics of Some Wrought and Cast Nickel-Base Alloys" presented before the 12th Annual Meeting of the ASLE *in Detroit, April,* 1957. *Preprint* 57*AM* 6*B*-1 *available from* ASLE, 84 *East Randolph St., Chicago.*

Stress Concentrations as Design Factors

By R. E. PETERSON
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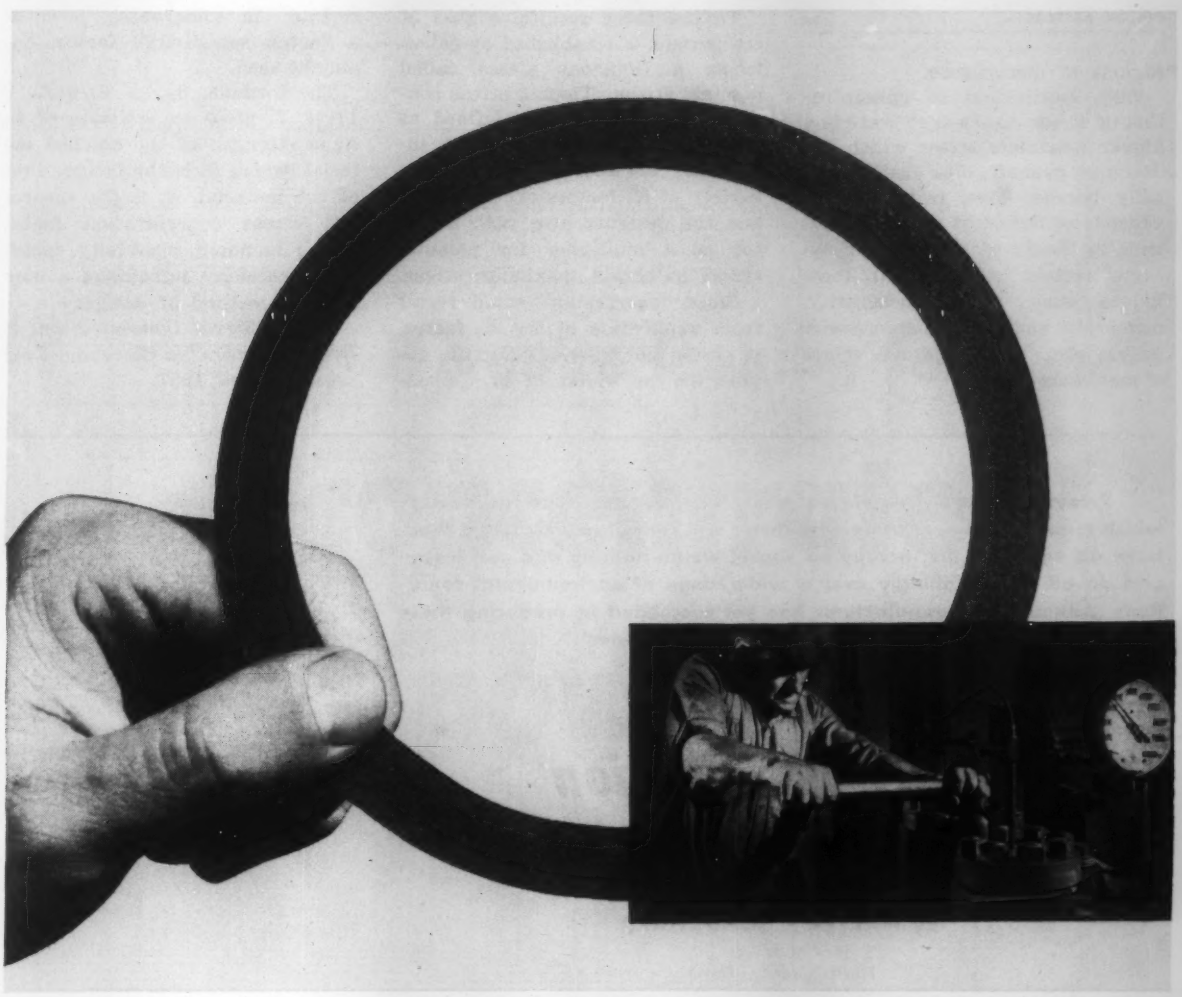
Research Laboratories
Westinghouse Electric Co.
Pittsburgh

ELEMENTARY stress calculations, i.e., uniform tension, simple bending and torsion, are directly applicable only when sections under consideration are uniform in cross section. However, machine parts are not made in this way since designers, of necessity, must introduce geometrical disturbances such as grooves, threads, notches, holes, etc., into the parts. These geometrical disturbances change simple stress distributions into more complex distributions which tend to localize stresses in



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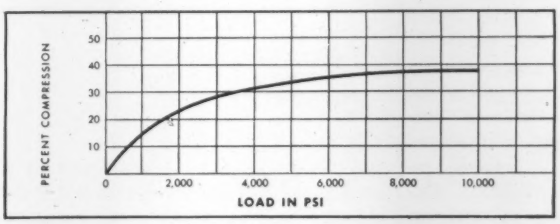

N-820 is made by a patented Armstrong process in which cellulose fibers are beater-saturated with a non-volatile, non-extractable latex binder. The result is a dense, crush-resistant material which has excellent torque-retention characteristics.

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regions of disturbance.

This localization or concentration of stress means that there is a higher maximum stress which the designer cannot solve mathematically because even rather simple geometries represent difficult problems in theory of elasticity. However, certain experimental techniques such as photoelasticity, membrane analogy, resistance-wire gages, etc., provide exact values of maximum stress.

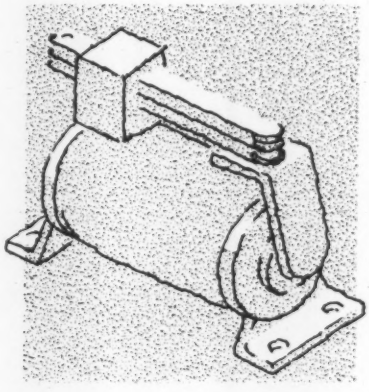
To use these results, a base of comparison is established by calculating a ficticious stress called nominal stress. Then, a stress concentration factor K_t is defined as the value of maximum stress divided by nominal stress. A large variety of K_t factors are available, and the designer uses such a factor as a multiplier for nominal stress to obtain maximum stress.

Since "overdesign" could result from application of the K_t factor, it should not be applied if the application or value of K_t is uncertain. In some cases, however, a "notch sensitivity" factor, 'S_{Kf}, may be used.

The formula, $S_{Kf} = S_f/q(K_t - 1) + 1$, gives an estimate of fatigue strength of the notched material, where S_f is the fatigue limit of the material, K_t is the theoretical stress concentration factor, and q is notch sensitivity factor. This procedure introduces a more rational method of design.

From "Stress Concentrations as Design Factors" in Cleveland Engineering, *April,* 1957.

Relays sought by engineers today can be described as devices which require no power to operate them, will control any kind of a load, have an unlimited life, occupy no space, weigh nothing and cost less—and do all this unfailingly over a wide range of environmental conditions. Although no manufacturer has yet succeeded in producing these perfect relays, the engineer can still profit by proper . . .



Relay Application

for satisfactory performance

By WALTER F. SCHUCHARD
S. H. Couch Co. Inc.
North Quincy, Mass.

RELAYS are considered reliable electronic components when their limitations are recognized and their application tailored accordingly. Results of an analysis brought about because of a disturbingly high incidence of failures indicated that failures, in excess of 40 per cent, were caused by misapplication. Expecting a relay to do a job for which it was never intended is perhaps the major contributing factor to the reputation enjoyed by relays today.

There are only three major considerations for proper selection and use of a relay:

1. Circuit requirements must be worked out so that critical values of operating and release currents and times are minimized.
2. Performance requirements must be worked out for each application. Blanket reference to existing specifications can cause considerable difficulty.
3. Mechanical mounting of the relay in the final package must be adequate. Mounting can often mean the difference between success and failure of the relay.

At the present state of the art, a relay for a special application necessarily represents a compromise. When and if a relay is designed that exceeds all application requirements by a factor of ten, its application can be reduced to elementary considerations.

Specifications must not be loaded with safety factors, but must reflect actual conditions as correctly as possible. Effect of different environmental conditions on performance of a simple dc-operated miniature hermetically-sealed relay will be considered. Environmental variables of interest are as follows:

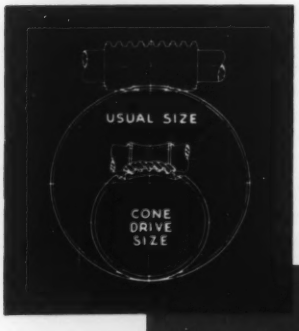
1. Ambient temperature.
2. Pressure (altitude).
3. Humidity.
4. Shock.
5. Mechanical vibrations.
6. Acoustical vibration.
7. Time, or effects of aging.
8. Radiation, nuclear and possibly cosmic.

Performance parameters include the following:

1. Operate current and voltage.
2. Release current and voltage.
3. Operate, transfer and release time.
4. Insulation resistance.
5. Dielectric strength.
6. Mechanical life.
7. Contact performance and action.

A relay is usually considered as a two-part device, an electromagnetic motor and a contact configuration

if you're looking for concentrated power



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representing mechanical load. While a designer has an almost unlimited number of variables at his disposal in designing a relay, for any given design, a slight change such as of contact gap or pressure will result in an end product that may have entirely different performance characteristics. Manufacturers take advantage of this in meeting special requirements. One of the biggest problems in relay manufacture is obtaining adequate control of mechanical variables so that uniform performance from unit to unit is assured.

Operate Current and Voltage: The relay motor is essentially a current-operated device. Operating current is affected only by conditions of vibration and shock which might cause physical displacement of the armature. These conditions can cause erratic operation of the motor when applied current is less than, but of the same order as operating current.

A well-designed relay will function at its operating current satisfactorily. Effect of temperature on magnetic properties of ferromagnetic materials is normally negligible. As maximum service temperatures increase, and special alloys with lower Curie points are called upon to meet ever-present pressure for miniaturization, it may be necessary to allow for changes due to temperature. Operating voltage depends upon operating current which is constant, and coil resistance which is variable depending upon temperature. Both ambient temperature rise and temperature from self-heating affect operating voltage.

Since copper is still the best conductor material available from a coil efficiency standpoint, operating voltage substantially depends upon temperature. Manufacturers' data should be consulted since the self-heating effect is a function of specific design.

Release Current: The current at which a relay will release is independent of temperature, but will be slightly larger when the relay is vibrated. Release voltage will depend upon coil temperature much the same as operating voltage.

Operate Time: Time interval between application of coil power and closing of all normally open contacts of a relay depends upon:

1. Basic mechanical and electrical design of the relay determine the range of operating time intervals required. Mass of the armature, inertia of the armature and movable contact elements, and electrical losses of the circuit all have a bearing on operating time of a relay.

2. For a given design, current overdrive and time constant of the circuit, including impedance of the power supply and series components, substantially affect operating time.

The greater the current overdrive and/or the smaller the time constant, the shorter the operating time. Therefore, a relay operated from a constant current source, such as is approximated by high-voltage power supply and a series current-limiting resistor several times larger than the resistance of the relay coil, will have essentially constant operating time regardless of environmental conditions.

A relay operated from a low-impedance voltage source with no appreciable series impedance, however, will have a variable operating time directly dependent upon temperature. This relationship is not linear since, at the same time, the time constant is reduced which partially compensates for reduction in current overdrive.

Transfer Time: Transfer time, or that interval of time during which the movable contact is in between the normally closed and normally open contact, is somewhat dependent upon operating time for operating transfer, and upon release time for release transfer, but basically is an inherent product of specific design.

Release Time: Release time is almost entirely dependent upon design parameters of the relay and can only be reduced by changing these parameters. It may, however, be increased by addition of external circuit components such as parallel resistors and spark suppression networks.

In applications where operating, release or transfer times are important, the relay manufacturer can frequently meet special requirements if allowed a latitude of freedom on other noncritical performance parameters.

Insulation Resistance: Insulation resistance of a hermetically-sealed relay will normally decrease with increasing temperatures. Other environmental conditions, with the exception of radiation, will not produce any effect unless the energy level of sustained vibration (acoustical or mechanical) is sufficient to actually cause disintegration of insulating materials. The other exception to this is effect of humidity in combination with dust, dirt and smoke on insulation resistance between terminals on the outside of the relay enclosure.

Dielectric Strength: Dielectric strength or voltage breakdown of a relay within its enclosure is practically independent of environmental conditions. Outside of the enclosure, however, humidity and pressure do affect this performance parameter. Since much electronic equipment is used at high altitudes, a thought worthy of consideration is that dielectric breakdown strength should be sufficient to meet requirements of the application at maximum altitude and nothing more. For example, why require 1000-v breakdown at sea level when actually the requirement might be only 100 v at an altitude of 70,000 ft.

Mechanical Life: Normally, mechanical life of a relay exceeds expected electrical life by such a large factor that it is of little interest. However, mechanical life is usually severely affected when critical levels of shock or vibration are exceeded, often resulting in permanent damage to the structural parts of the relay.

Contact Performance: Contact erosion at rated loads or overloads is accelerated at elevated temperature, and contact life is inversely dependent upon contact load. Ordinarily, contact resistance is used as a measure of contact deterioration during life testing. Changes of resistance can result in modulation of the intelligence signal being switched by

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the contacts which, in some cases, can produce equipment malfunction. Vibration can produce dynamic changes in contact resistance.

In general, contact resistance of a relay is considered to be a fraction of an ohm which is quite correct for properly functioning contacts carrying current of the same order as rated current.

Contact bounce or chatter is inherently present when two solid-state metal members are brought into contact with each other. Environmental conditions probably have little effect upon this phenomenon, but current and voltage level of the controlled circuit may materially affect the observed effect. Vibration and shock can produce momentary contact separation and, under extreme conditions, actual contact transfer.

From a paper entitled "Relays as Reliable Electronic Components" presented at the Second RETMA Symposium on Applied Reliability in New York, June, 1957.

Checkpoints for Design Improvement

By R. B. WILSON
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Convair—Astronautics
Div. of General Dynamics Corp.
San Diego, Calif.

DESIGNERS must give careful consideration to all anticipated environments and system requirements in developing specifications and creating designs to satisfy those specifications. Certain general, mechanical and electrical checkpoints are useful for improving initial design. The following checkpoints have been compiled from experience as factors which contribute to soundness of design.

General:

1. Use standard, well-developed parts.
2. Select vendors whose performance is proven.
3. Simplify design wherever possible.
4. Establish fits and tolerances consistent with performance requirements.
5. Allow for environments and aging which cause tolerance changes.
6. Reject parts out of tolerance.
7. Provide controls logically close to corresponding displays.
8. Provide reasonable operating procedures.
9. Provide adequate cooling for heat-generating equipment.
10. Provide adequate clearance between components to prevent damage during shock conditions.
11. Provide proper finishes for corrosion resistance.
12. Provide easy maintenance accessibility.
13. Provide proper assembly tools.
14. Promote careful inspection after fabrication.
15. Provide adaquate protection during storage.

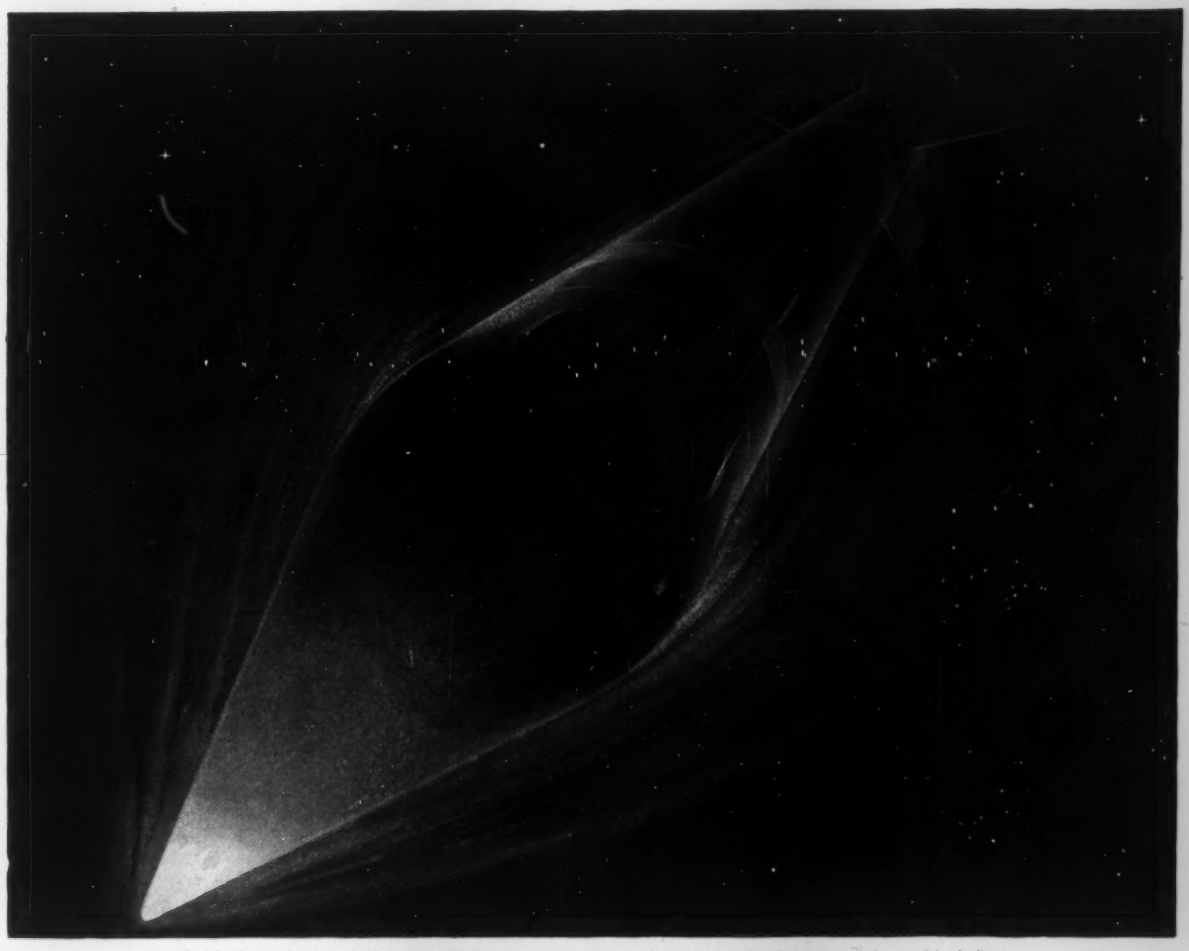
Mechanical:

1. Provide sufficient clearances for adjustment and/or travel.
2. Provide reliefs or clearances adequate for subsequent operations.
3. Allow for environmental changes in providing bearing clearances.
4. Provide assembly ramps for seals.
5. Select fasteners of adequate size to hold components together and in place.
6. Keep stainless steel screws identified and separated from cadmium-plated screws.
7. Provide adequate locking methods for screws and other fasteners.
8. Secure gears to shafts with preferred pins rather than set screws.
9. Provide a design that is free from points of high stress concentration.
10. Provide adequate gaskets for enclosure covers.
11. Specify finishes that do not interfere with operation of hydraulic or pneumatic components.
12. Provide adequate clearances for special assembly tools.

Electrical:

1. Locate cable entrances where they will not be disturbed by removing access panels.
2. Provide comfortable access to terminal strips.
3. Provide extra terminals on terminal strips for unexpected needs or changes.
4. Mark terminal strips and component boards in a permanent manner.
5. Consider environmental effect on resistors and capacitors so that there is a selection of sufficient rating or derating of the manufacturer's rating.
6. Provide adequate margin in circuits including electronic tubes to hold tube failures to a minimum.
7. Consider environmental vibration which causes relays to chatter, timers to fail, soldered wire joints to break, etc.
8. Specify complete identification on potted networks.
9. Provide adequate protection for wires and cables passing through partitions or components.
10. Specify only rosin-base fluxes of proven noncorrosive properties in soldering.
11. Specify proper production sequence.
12. Specify proper insulating materials.

From a paper entitled "Designing Equipment for Reliability" presented at the Semi-Annual Meeting of the ASME in San Francisco, June, 1957.



Sustained operating temperatures up to 400° F, as in guided missiles, are death to inferior electrical insulations and laminates. CDF glass-base laminates of Teflon*—the only laminates of their kind approved by the military—can take this punishment steadily.

LATEST HIGH-HEAT INSULATION SYSTEMS NEED CDF GLASS-BASE LAMINATES AND TAPES

Widest available range offers Teflon, epoxy, silicone, mica products for dimensional stability under continuous heat

As components and equipment grow smaller, and heat becomes more difficult to dissipate, CDF high-heat electrical insulations become increasingly important to electronic design. For nowhere else can such a wide range of quality insulations be found under one roof as at CDF.

FOR HIGH-HEAT PRINTED CIRCUITRY, CDF glass-base metal-clad laminates of Teflon* and epoxy exhibit best dimensional stability and current-carrying capacity. Constant operating temperatures of 300°F — soldering temperatures to 500°F — are readily met by these specialized CDF Dilecto® laminates.

HIGH-HEAT FLEXIBLE INSULATIONS. CDF offers a wide choice of insulating tapes made of Teflon, silicone varnish, silicone rubber, and Micabond®, with glass-cloth support. CDF tapes may be used either by hand wrapping or on automatic winding machines. Unsupported Teflon in colors available to meet MIL-STD 104.

TEFLON SPAGHETTI TUBING AND OTHER SPECIALTIES. Part of CDF's vast fabrication facilities is devoted to the production of custom parts from Teflon — spaghetti tubing, rods, sheets, and machined parts to rigid specifications.

NEW — *cementable* Teflon, bondable to itself and to other materials with commercial adhesives.

SEE SWEET'S Product Design File, Electronics Buyers' Guide, and other directories for the name and phone number of your CDF sales engineer. Then send your print or your problem, and we'll return specific technical data and test samples.

*trademark of DuPont tetrafluoroethylene resin

CDF CONTINENTAL-DIAMOND FIBRE
A SUBSIDIARY OF THE Budd COMPANY • NEWARK 23, DEL.

Circle 470 on page 19

Helpful Literature
for Design Executives

For copies of any literature listed, circle Item Number on Yellow Card—page 19

AC & DC Voltmeters

Data sheet 875 lists 126 models of Beckman expanded scale alternating and direct-current voltmeters. They are available in both military and commercial models, in a wide range of sizes, shapes and voltage values. 4 pages. Helipot Corp.

Circle 631 on page 19

Seamless & Welded Pipe

Technical Data Card 138 B on carbon, alloy and stainless steel seamless and welded pipe provides two tables which list dimensions, weights, specifications, grades and analyses for 16 sizes from ⅛ to 8 in. 4 pages. Babcock & Wilcox Co.

Circle 632 on page 19

Precision Switches

Folder V-2-7 describes precision Micro switches for limit, indicating and interlock uses, and data sheet 117 specifies buttons for light push-button switches. Uses for explosion-proof switches are shown. 4 and 2 pages. Minneapolis-Honeywell Regulator Co., Micro Switch Div.

Circle 633 on page 19

Spin Locknuts

Brochure describing M-F Spin-Lock nuts emphasizes the ratchet-like structure of the nut which provides the locking feature. One-piece construction speeds assembly. Comparative torque values are given. 4 pages. MacLean-Fogg Lock Nut Co.

Circle 634 on page 19

Torque Testing Fixtures

Typical applications are highlighted in bulletin TTF-7 on torque testing fixtures for lab, inspection or production use. Fixture takes standard drivers, sockets and internally threaded collets available for all screws. 4 pages. P. A. Sturtevant Co.

Circle 635 on page 19

Aluminum Mill Products

A condensation of the Mill Products Catalog for 1957, this Reynolds booklet is a reference guide for preliminary discussion of design and fabrication. Information on industrial foil and revised weight charts for wrought and casting alloys is featured. Data are provided on wrought alloys in sheet, plate and foil, wire rod and bar, tubing and pipe, extruded and structural shapes, and for casting alloys. 18 pages. Reynolds Metals Co.

Circle 636 on page 19

Variable Transformers

Technical data on the LW 136 Powerstat variable transformer provided in bulletin SE-L3578 includes connection diagrams and ratings when unit is used as a source of adjustable low voltage isolated output, a limited range line corrector, or as a limited range "buck-boost" variable transformer. 4 pages. Superior Electric Co.

Circle 637 on page 19

Glass Parts

Custom-made glass parts for industrial, electronic and commercial applications are shown in brochure "Glass . . . to Brighten Your Product's Future." Parts are produced by molding, pressing and blowing. Grinding and polishing, sealing, bending, silvering and decorating are also covered. 8 pages. Lancaster Lens Co.

Circle 638 on page 19

Blind Rivets

Advantages of two types of blind rivets are listed with typical applications in form 8-409. Dimensions, ranges and tolerances of pull-through and self-plugging types are provided. One page describes five driving tools. 10 pages. Huck Mfg. Co.

Circle 639 on page 19

Precision Castings

"How to Design Precision Investment Castings" is second edition of this informative guide to design principles, case histories of typical precision parts and other data on investment castings. Material selection chart gives physical properties of various metals and alloys that can be investment cast. 16 pages. Midwest Precision Castings Co.

Circle 640 on page 19

Standard Electric Motors

Application and selection information on line of standard electric motors is provided in brochure 194. Motors are offered in dripproof, totally enclosed fan-cooled, single-phase dripproof, vertical flange mounted and explosionproof designs. 12 pages. Sterling Electric Motors, Inc.

Circle 641 on page 19

Power Transmission Equipment

V-drives, sheaves, drive belts, couplings, paper pulleys, steel keys, collars, and roller chain and multiple belt drives are listed in stock sizes in brochure GC-101-D. 20 pages. Browning Mfg. Co.

Circle 642 on page 19

Flexible Couplings

Horsepower ratings, dimensions, maximum speed and other engineering data necessary for the selection of the correct flexible coupling for any application are listed in catalog 7. These chain type couplings are available with finished bore and Taper Lock bushings. Diamond Chain Co.

Circle 643 on page 19

Custom-Made Items

Engineering and production facilities of this company that are available for the production of custom ferrous and nonferrous products are described in illustrated bulletin. Standard line includes rivets, burrs, staples and metal fasteners. Cobb & Drew, Inc.

Circle 644 on page 19

Spring Steels

Catalog portion of bulletin SB-501, which covers company service facilities, gives specific information on spring and specialty strip steels. Each type is listed by applications with material, finish, usual size range and chemical analysis given for each. 6 pages. Sandvik Steel, Inc.

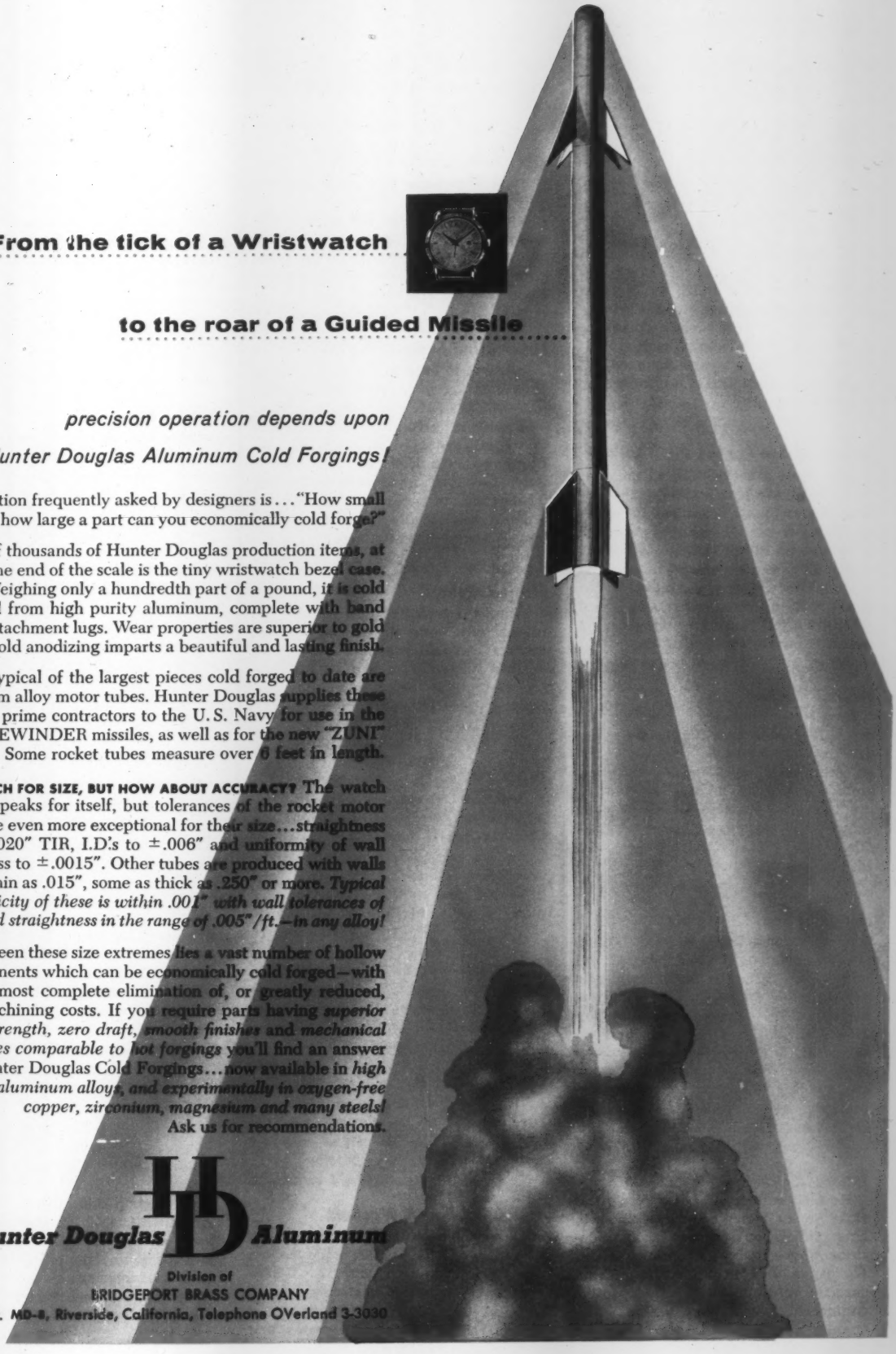
Circle 645 on page 19

Hydraulic System Components

Product information and engineering data on hydraulic pumps, fluid motors, aircraft-type pumps and servo

From the tick of a Wristwatch

to the roar of a Guided Missile



precision operation depends upon

Hunter Douglas Aluminum Cold Forgings!

A question frequently asked by designers is... "How small or how large a part can you economically cold forge?"

Out of thousands of Hunter Douglas production items, at one end of the scale is the tiny wristwatch bezel case. Weighing only a hundredth part of a pound, it is cold forged from high purity aluminum, complete with band attachment lugs. Wear properties are superior to gold and gold anodizing imparts a beautiful and lasting finish.

Typical of the largest pieces cold forged to date are aluminum alloy motor tubes. Hunter Douglas supplies these as prime contractors to the U. S. Navy for use in the SIDEWINDER missiles, as well as for the new "ZUNI" rocket. Some rocket tubes measure over 6 feet in length.

SO MUCH FOR SIZE, BUT HOW ABOUT ACCURACY? The watch case speaks for itself, but tolerances of the rocket motor tubes are even more exceptional for their size...straightness to .020" TIR, I.D.'s to ±.006" and uniformity of wall thickness to ±.0015". Other tubes are produced with walls as thin as .015", some as thick as .250" or more. *Typical concentricity of these is within .001" with wall tolerances of .002" and straightness in the range of .005"/ft.—in any alloy!*

Between these size extremes lies a vast number of hollow components which can be economically cold forged—with almost complete elimination of, or greatly reduced, machining costs. If you require parts having *superior strength, zero draft, smooth finishes* and *mechanical properties comparable to hot forgings* you'll find an answer in Hunter Douglas Cold Forgings...now available in *high strength aluminum alloys, and experimentally in oxygen-free copper, zirconium, magnesium and many steels!* Ask us for recommendations.

Hunter Douglas Aluminum

Division of
BRIDGEPORT BRASS COMPANY
Dept. MD-8, Riverside, California, Telephone OVerland 3-3030

Circle 471 on page 19

systems are featured in revised bulletin 810 on hydraulic system components. Pump-motor combinations shown deliver up to 10 gpm at up to 1500 psi. 16 pages. Eastern Industries, Inc.

Circle 646 on page 19

Pressure Gages

Helicoid pressure gages for industrial, processing and chemical applications are graphically presented in illustrated catalog G-52. Design and operating details are given on these instruments which resist pressure pulsations, shock and vibration. Dimensional drawings are included. 32 pages. American Chain & Cable Co., Helicoid Gage Div.

Circle 647 on page 19

Rotary Piston Pump

Developed expressly for lubrication of vertical shaft machinery, the rotary piston pump described in bulletin TR-57-A can be mounted on upper or lower end of the machine shaft. It forces oil through an axial hole in the shaft. This easily mounted sump pump will provide continuous flood lubrication of bearings and gears. 2 pages. Bijur Lubricating Corp.

Circle 648 on page 19

Electric Brakes

Details of the redesigned line of series E electric disk brakes are given in illustrated bulletin SK-4896. Available in sizes suitable for use on motors rated up to 75 hp, brakes provide for split-second stopping of heavy loads. 8 pages. Safety Industries, Inc., Star-Kimble Industrial Motor Div.

Circle 649 on page 19

Hermetic Seal Terminals

Specifications for a wide variety of standard Hermetic seal single terminal feed-throughs and stand-offs are contained in supplementary catalog No. 657-B. Vac-tite seals employ glass-to-metal construction which assures leakproof operation. Drawings give dimensions of these units which are available hot tin dipped or with precious metal finishes. 12 pages. Hermetic Seal Corp.

Circle 650 on page 19

Technical Data Books

Revised catalog of Lefax Technical Data Books, which sell for $1.25 each, lists titles for engineers and designers. Each book contains about 140 pages of information and data on specific subjects such as automotive engineering, machine design, mechanics of materials, metals, motors and generators, welding, physical and thermodynamic data, and conversion tables. Lefax Publishers.

Circle 651 on page 19

Electric-Hydraulic Control

Illustrated data sheet and detailed drawings comprise bulletin A-102 on a motorized actuator for relief valve and pump control. Device will control and modulate 5000-psi hydraulic pressure with 15-w electric power. 5 pages. United Hydraulics, Inc.

Circle 652 on page 19

Lubricating System

Lubrival is described as a new type of circulating oil system for application on presses and semiautomatic and automatic machines and machine tools in illustrated bulletin No. 70. Equipment monitors its own operation through a pressure-sensing mechanism to warn of clogged or broken lines in any part of the system. 8 pages. Farval Corp.

Circle 653 on page 19

Electric Relays

Five Star sensitive and power type relays with coils in various voltage ratings for alternating and direct current service are detailed in illustrated bulletin. Enclosed and hermetically sealed types are offered. 4 pages. Five Star Co.

Circle 654 on page 19

Wire

Ordering specifications and other information are given in illustrated CF&I-Wickwire catalog. Descriptions are included on such types as low-carbon coarse, high-carbon fine, specialty, flat and shaped wire. 72 pages. Colorado Fuel & Iron Corp.

Circle 655 on page 19

Automatic Valves & Controllers

Function, application, construction and range of sizes for each unit in the complete line of pressure reducing, regulating, relief, back pressure and control valves; controllers; differential regulators, oil pumping units; and combination and temperature regulators are covered in catalog No. S-730-1. 8 pages. A. W. Cash Co.

Circle 656 on page 19

Nylon Bobbins & Washers

Dimensions and available shapes of stock nylon bobbins and washers are listed in bulletin BW657. Washers range in outer diameters to 1½ in. and in 0.018 to 0.093-in. thicknesses. Bobbins for coil forms and transformers are offered in variety of geometric shapes with flanges up to 2 x 2½ in., cores from ⅛ to 1½ in. and core lengths from ¼ to 1½ in. 4 pages. Cosmo Plastics Co.

Circle 657 on page 19

Decimal Equivalent Chart

Three-color wall chart contains easily-read decimal equivalents of fractions to 1/64th from 0 to 1. Decimals run down center of each of two columns, with 64ths to the right and 32nds and 16ths to the left. Chart is free to designers. Size is 16 x 23 in. John Hassall, Inc.

Circle 658 on page 19

Plastic Pipe Fittings

Technical data and installation information on polyvinyl chloride pipe are contained in illustrated booklet. It also gives specifications for threaded and socket type PVC fittings, valves and flanges made of normal and high impact material. Charts, tables and formulas amplify the text. Tube Turns Plastics, Inc.

Circle 659 on page 19

Vibration Damping Mount

Adaptable for loads up to 10,000 lb per mount, Adjust-O-Mounts are suitable for installing wide range of equipment and machine tools. These all-metal vibration absorbers have a built-in leveling device. Machines need not be fastened to floor. Details of mounts are given in bulletin 2000. 4 pages. Robinson Aviation, Inc.

Circle 660 on page 19

Rotary Gear Pumps

Design and performance data on five new series of Wayne internal-gear rotary pumps are presented in catalog WI-054. Types of pumps available include standard duty, Underwriters' approved, packaged, mechanically sealed and steam jacketed. Operating pressures range to 200 psi and capacities to 313 gpm, maximum. 20 pages. Wayne Pump Co., Industrial Div.

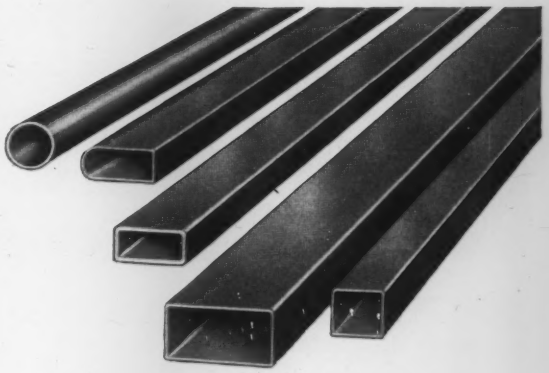
Circle 661 on page 19

Bimetal Thermostats

Operating principle of type W bimetal strip thermostats is described in bulletin 4000. Thermostats are used in refrigerators, rectifier fans electronic and avionic devices, and industrial apparatus requiring precise control of high-wattage heater loads. 2 pages. Stevens Mfg. Co.

Circle 662 on page 19

Another Plus . . . from Brainard



Tubing:

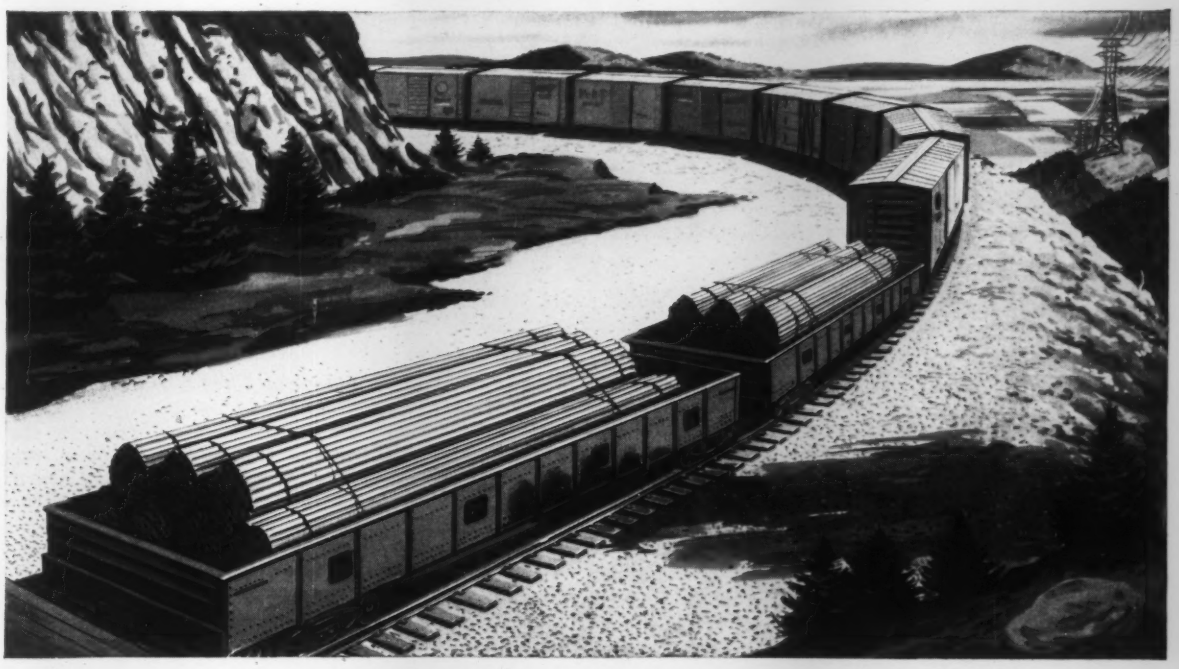
Assured delivery from an integrated mill...

As a buyer of steel tubing, what does the phrase . . . "from an integrated mill" mean to you?

To most of our customers it means just this: no company likes to have its markets jeopardized by production slow downs resulting from material shortages. When the "material" happens to be tubing and the supplier is an integrated mill such as Brainard, such shortages are virtually non-existent.

As an integrated mill, Brainard is not dependent on outside material sources. The corporation of which Brainard is a part controls tubing production from raw material source to finished product: thus customers are assured of an uninterrupted supply.

So, whether you buy tubing in small quantities or carload lots, you can benefit from this year-in-year-out dependability of supply by placing your orders with Brainard.



Brainard Steel Tubing

SHARONSTEEL

Brainard Steel Division, Sharon Steel Corporation
Griswold Street, Warren, Ohio

258

FOR YOU FROM
ROPER...
THIS FACT-PACKED BOOK

32 Pages of Ready Reference Including:

- Factors on Pumping Problems
- Sample Problems Figured for Guidance
- Technical Data . . . Piping Charts
- Conversion Tables . . .Viscosity Tables

Plus other information that is helpful to you

SEND FOR YOUR PERSONAL COPY TODAY!

ROPER
Rotary Pumps

GEO. D. ROPER CORPORATION
248 Blackhawk Park Avenue
Rockford, Illinois

Helpful Literature

Drafting Shortcuts

"Time Saving Tips for the Draftsman and Engineer" is title of booklet which compiles 59 tips and drafting shortcuts suggested by leading engineers and designers. Suggestions include: Remembering trig functions, dividing a circle into parts, locating decimal points, constructing an approximate ellipse and determining gear inertia. 44 pages. Frederick Post Co.

Circle 663 on page 19

Air & Oil Hydraulic Components

Cylinders, pumps, power units, valves, motors and accessories comprise line of air and oil hydraulic components reviewed in condensed catalog 1101. Pumps, motors and power units covered are fixed and variable displacement types rated 1 to 85 gpm at 1000 and 3000 psi. 28 pages. Hydraulic Press Mfg. Co.

Circle 664 on page 19

Valve Actuator

Model RF-697 Electrohydraulic valve actuator is designed for use with low level ac or dc signals from electronic controllers and measuring elements or remote positioning devices. It can be mounted on valves with ½ to 1½-in. stroke, requiring less than 200-lb thrust. Bulletin 38.3 provides details. 4 pages. Askania Regulator Co.

Circle 665 on page 19

Fine-Grain Phosphor Bronze

Why Flexograin fine-grain phosphor bronze is superior to coarser-grained types for many applications is explained in technical bulletin T-4. Various applications are graphically illustrated. 4 pages. H. K. Porter Co., Riverside-Alloy Metal Div.

Circle 666 on page 19

Industrial Tires & Wheels

All phases of industrial tire use are explained in illustrated guide book on industrial tires and wheels. Book describes company's complete line, the use of each type of tire, variations in pneumatic tire capacities at various speeds, wheel and caster combinations available, latest truck tire specs and how to change steel wheels to rubber-tired wheels. 36 pages. B. F. Goodrich Tire Co.

Circle 667 on page 19

Industrial Wire Cloth

Illustration of company's complete line of industrial wire cloth, screens and wire cloth products is given in comprehensive catalog. Types and sizes, and typical applications are listed. A new section gives stand-

NOW!

CONSTANT TORQUE VARIABLE SPEED

units to match the high performance standards of BOSTON Gear SPEED REDUCERS

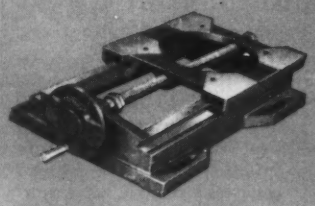
BOSTON Gear STANDARDIZED STOCK VARIABLE SPEED DRIVES

BOSTON VARIABLE SPEED DRIVES

Assembly consists of a self-contained, spring-tension Motor Pulley, a Flat Face Driven Pulley, a heavy duty Belt, and an Adjustable Motor Base. The self-contained design of the Motor Pulley provides a patented safety-lock feature which prevents accidental release of the spring when the disc assembly is removed.

BOSTON VARIABLE SPEED REDUCTOR DRIVES

Consists of above described parts with addition of a BOSTON 100 Series Reductor, — Type U, TW, V, or VW. Illustration (right) shows Variable Speed assembly with Type TW Reductor, used with BOSTON Sprockets and Chain to drive conveyor belt of heat-treating furnace.



ADJUSTABLE MOTOR BASE

A ruggedly proportioned sliding platform, with accurately machined dovetail ways, lead screw, and nut for positive control and vibrationless, noise-free operation. Sold separately, this base is also widely used for many other applications requiring an adjustable motor mounting.

Designed for use with ½ and ¾ HP motors, to provide infinitely variable, 3 to 1 speeds. Speed changes can be made while the drive is running. Output torque ratings remain constant throughout the speed variations. Any driven shaft speed range needed, between 1750 RPM and .5 RPM, can be provided with the use of STANDARDIZED STOCK parts.

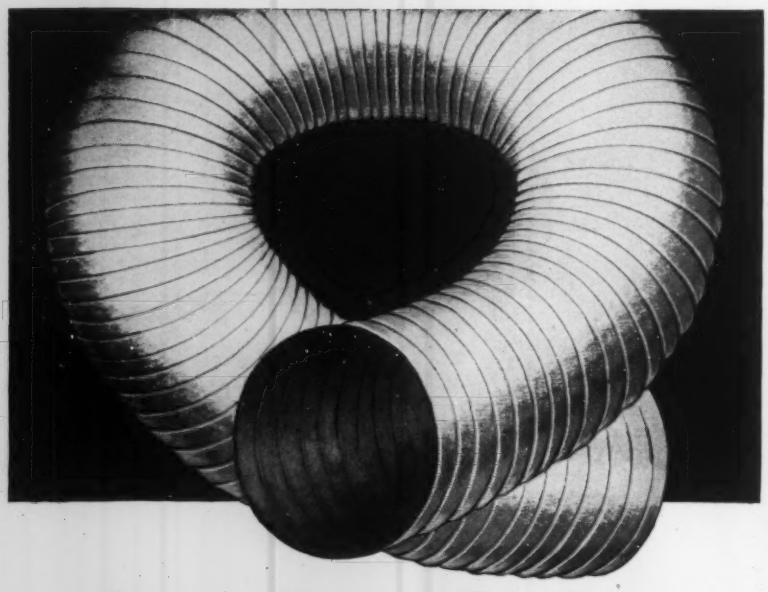
Ask your BOSTON Gear Distributor for complete information and a demonstration at your plant. Boston Gear Works, 64 Hayward St., Quincy 71, Mass.

7124 POWER TRANSMISSION PRODUCTS FROM STOCK

CALL YOUR BOSTON Gear DISTRIBUTOR

For nearest Distributor LOOK UNDER "GEARS" in the 'Yellow Pages'

STOCK GEARS • SPROCKETS and CHAIN • SPEED REDUCERS • BEARINGS • COUPLINGS



facts about Flexflyte®

that will help you solve a ducting design problem

What is Flexflyte?
A lightweight, reinforced ducting made of a spring steel wire helix covered with coated fiber glass or a cotton fabric and bound with a fiber glass cord.

What are its applications?
Equipment designers will find Flexflyte ideal for applications where an unobstructed flow of air, gases, liquids, chemicals, light solids must be maintained.

How flexible is Flexflyte?
It will take tight turns at any point up to 180° without buckling. No elbows or fittings are required.

What are its temperature ranges?
From minus 120°F. to plus 650°F.

What pressures will Flexflyte handle?
Internal working pressures up to 70 psi and external working pressures up to 15 psig.

Is it flame resistant?
Flexflyte has exceptionally high flame resistance and will not support combustion.

What about Flexflyte's resistance to abrasion?
It is highly resistant to abrasion, especially when coated with FT-506 which has more than 200 times the abrasion resistance of any tubing of its type and weight.

What about installation?
Flexflyte is quickly, easily installed around corners and equipment parts by means of metal clamps. It is also available with special enlarging or reducing ends, either cylindrical, rectangular or polyhedral.

Can Flexflyte be engineered for unusual applications?
Yes. Special fabrics, coatings, connections, lengths and diameters are available. Our special Silicone Department, working with automated machinery, is prepared to meet any requirement for silicone ducting.

How can I make sure that Flexflyte will solve my problems?
Write us, outlining your requirements. Our engineers will be glad to put their experience to work for you. Write Dept. 188.

Flexible Tubing
CORPORATION
GUILFORD, CONN. • LOS ANGELES 64, CALIF.

Helpful Literature

ard trade definitions and ordering information. Sizes range from 1 to 100 meshes per lineal inch. 94 pages. Cambridge Wire Cloth Co.

Circle 668 on page 19

Teflon Industrial Hose

Construction and use of 2802 industrial hose made of Teflon and featuring reusable fittings is described in engineering bulletin IEB-26A. Hose excels in uses requiring lubricity, nonadhesion of viscous materials, resistance to 500° F, chemical inertness and long wear. 4 pages. Aeroquip Corp.

Circle 669 on page 19

Thermal Disk

"The Story of the Spencer Disc" is title of pocket-size, second-issue booklet which describes origin of this thermal element and how it actuates Klixon thermostats, circuit breakers and inherent overheat motor protectors. 32 pages. Metals & Controls Corp., Spencer Thermostat Div.

Circle 670 on page 19

Aircraft Filters

Recently developed micro-magnetic filters for aircraft and missile use are designed to trap sub-micronic ferrous particles by magnetic action, as well as 10-micron particles by mechanical action. Complete description is given in illustrated catalog 54-100 6 pages. Cuno Engineering Corp.

Circle 671 on page 19

Hydraulic Components

Piston pumps, valves, motors and cylinders are among hydraulic circuit components described in bulletin DG-2. These lightweight, compact units operate at 3000 to 6000 psi pressures and are up to 95 per cent efficient. 4 pages. Dynex Inc.

Circle 672 on page 19

Flow Rate Control

A flow chart, dimensional information and cross-sectional illustrations of a Flush-Flo special purpose flow rate control are provided in bulletin 237. The Flush-Flo is a backwash control for water softeners. 4 pages. Hays Mfg. Co.

Circle 673 on page 19

Surface Roughness Standards

American Standard booklet on surface roughness defines geometric irregularities of solid material surfaces and physical specimens for gaging roughness. It establishes definite classifications for roughness, waviness and lay, as well as a set

Circle 475 on page 19

TENSION - TO KEEP YOUR BOLTED ASSEMBLIES TIGHTER LONGER

Wherever products are subject to movement, vibration, stresses and strains, more than tight fastenings are necessary to keep assemblies tight indefinitely. There must be constant tension in the assemblies and the one sure way to accomplish this is by the use of famous Reliance Spring Lock Washers. They not only retard "nut creep," but automatically compensate for bolt stretch, thread wear, expansion and contraction due to temperature changes.

Made of cold drawn spring steel in Reliance's own cold finished mill, the Spring Lock Washers are quality controlled throughout their manufacture and offer the reactive range and pressure necessary to keep bolted assemblies tighter longer. Reliance Spring Lock Washers have proved for fifty years an accepted standard in industry, and are produced in four standard series: light, medium, heavy and extra heavy for each screw and bolt size.

For more information please write for Engineering Bulletin W-50 or request a visit from one of our fastening engineers.

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825-pound Pintle Bushing, for a hydroelectric power project

NBD ...TOPS FOR BIG BRONZE BUSHINGS...

NBD is geared for big stuff like this, or smaller parts, long-run . . . bushings, bearings, gear blanks, pump parts. We cast them in weights up to 20,000 lbs. Machined to any degree of finish, in diameters up to 72 inches. Precise tolerances held to your specifications.

NBD specializes in bronze metallurgy and casting techniques; has developed more than 40 special alloys. Completely equipped for shell mold, cast-to-size and centrifugal casting.

For top quality and know-how in bronze castings, call or write us for quotes or information.

AMERICAN Brake Shoe COMPANY

NATIONAL BEARING DIVISION

4930 Manchester Avenue • St. Louis 10, Missouri

PLANTS IN: CHICAGO • ST LOUIS • MEADVILLE, PA.

Circle 477 on page 19

Helpful Literature

of symbols for drawings, specifications and reports. 24 pages. Brush Electronics Co.

Circle 674 on page 19

Heavy-Duty Switches

Six series of heavy-duty precision Micro Switches are described with their respective actuator designs and contact arrangements in bulletin 84-274. Switches are intended for machine tool and equipment use. 4 pages. Minneapolis-Honeywell Regulator Co., Micro Switche Div.

Circle 675 on page 19

Subminiature Resistors

Data sheet 150 provides specifications and list of ratings for Little Devil subminiature molded composition resistors. They are offered in ± 10 per cent RETMA resistance values from 100 ohms to 1.0 megohm. Ohmite Mfg. Co.

Circle 676 on page 19

Liquid Chemical Feeder

Bulletin 575 features the Clarkson model E feeder in 18-8 stainless steel for controlled feeding of liquids. Capacities range from as little as a few drops for single units to 2400 gallons per day for triplex feeders. 4 pages. Clarkson Co.

Circle 677 on page 19

Dry Fluid Drive

Bulletin A654 describes a larger size of the Flexidyne dry fluid drive introduced two years ago. Horsepower ratings are 50 per cent over maximum recommended for earlier drives and couplings, and sizes range to 75 hp at 1750 rpm. Bulletin supplements bulletin A-640A and is being offered with general line bulletin A-646A, both of which are available. 4 and 8 pages. Dodge Mfg. Corp.

Circle 678 on page 19

Self-Locking Nuts

Forty-nine per cent lighter than their standard counterparts, SPS self-locking nuts are reviewed in catalog folder 2321. The forged, all metal nuts meet weight-saving demands of the aircraft industry and employ a three-point locking action. 4 pages. Standard Pressed Steel Co.

Circle 679 on page 19

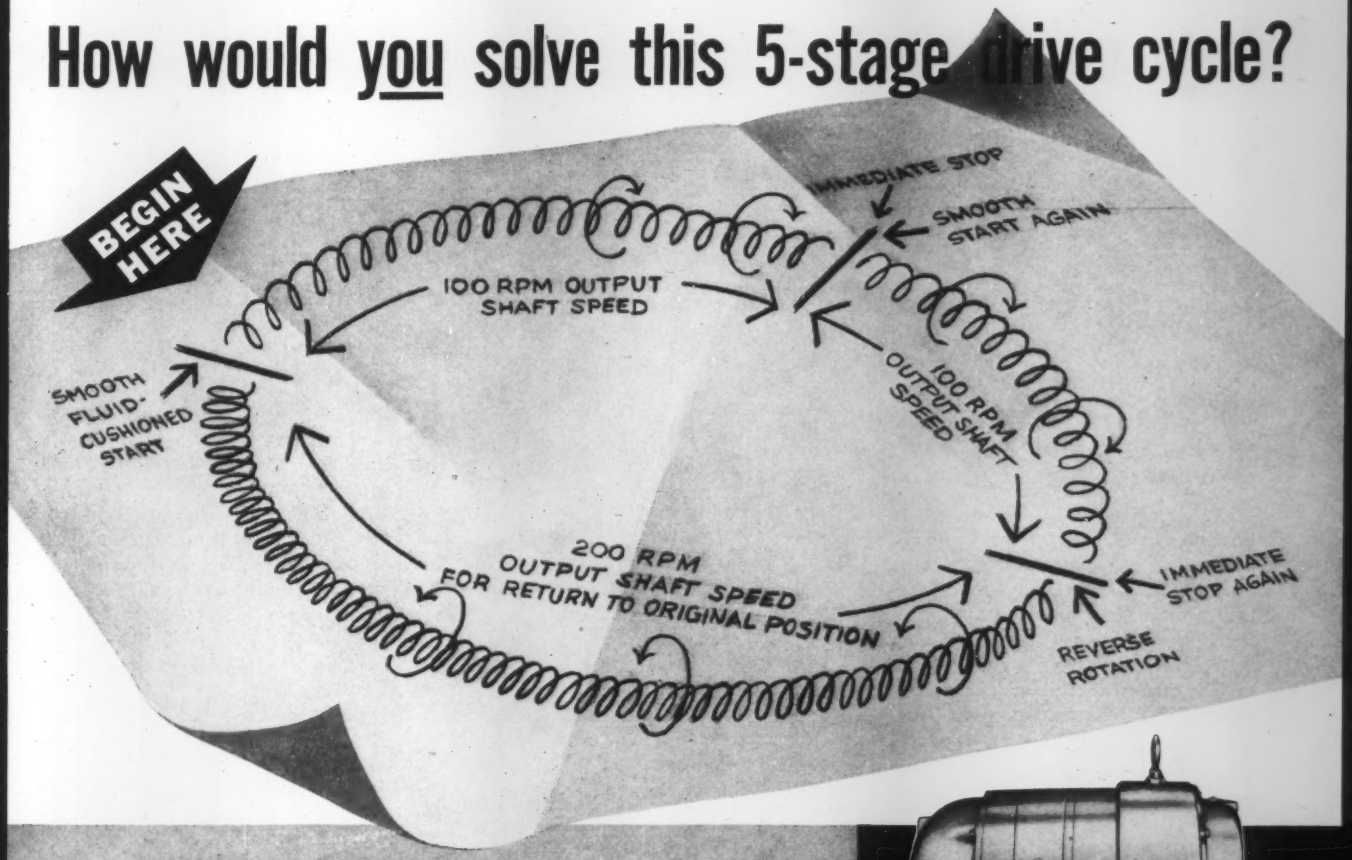
Stainless Tubing & Pipe

Company facilities for making stainless tubing and pipe are effectively illustrated and described in available brochure. Dimensions are tabulated on ⅜ to 3-in. OD tubing. 8 pages. Damascus Tube Co.

Circle 680 on page 19

Circle 478 on page 19→

How would you solve this 5-stage drive cycle?



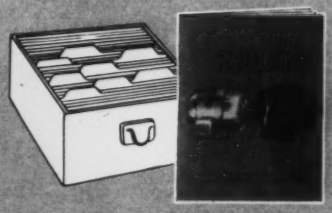
This one *modern* Reuland power package *does* all five!

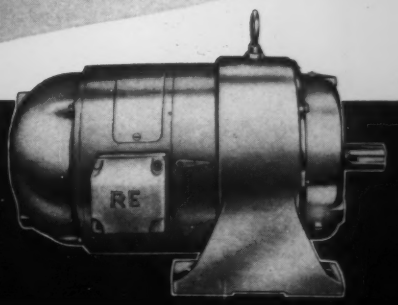
Today's ingenous, automatic machines have demanded a whole new concept in electric motors. No longer will "just any motor do" because the motor now becomes merely an integral part of the modern drive *package*.

Reuland's "Xpandable Design" idea *originated* this modern new approach several years ago. With this unique system, drives incorporating many varied factors are supplied as a single unit . . . *tailored to the needs of each individual customer*.

Modern Reuland Power demonstrates every day that there *is* something new in electric motors. Whether *your* own drive needs are more complicated, or less, than the above sketch . . . it will pay you to take stock and compare with what Reuland can offer.

Our New General Catalog Will Come In Handy — Sent FREE On Request
Gives details on Reuland's "Xpandable Design" . . . also shows how O.E.M.'s save money by using Reuland's free "Special Motor Library." Get a copy for your files now, for sure.





MODERN REULAND POWER

This unit contains an internal fluid coupling . . . a two-speed reversing duty motor . . . gear reducer . . . and magnetic brake mounted between the reducer and the fluid coupling. It is typical of the literally hundreds and hundreds of tailored adaptations available as a result of Reuland's modern "Xpandable Design" idea.

It is easy to see how this one, compact drive package saves costs and space and weight in comparison to installing separate drive units.

MODERN POWER FOR MODERN-DAY PRODUCTS

REULAND MOTORS

REULAND ELECTRIC COMPANY

WESTERN DIVISION: Alhambra, California
EASTERN DIVISION: Howell, Michigan
DISTRIBUTORS IN ALL PRINCIPAL CITIES

* REGISTERED TRADEMARK

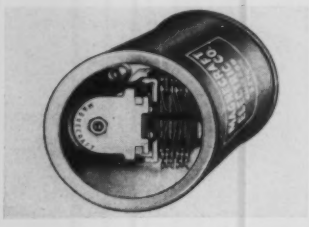
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Enclosed Relay

has plastic observation window

Visual inspection of contacts is possible in a plug-in relay incorporating a plastic observation window. Dust-tight enclosure is of metallic construction with heavy transparent plastic insert in one end. Unit is available for ac and dc operation with contact combinations to six-pole, double-throw. It can be furnished with contacts



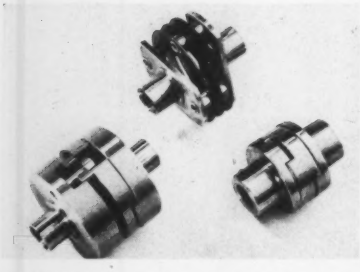
ranging from bifurcated (twin) contacts for switching extremely low voltage and low current to power contacts rated 10 amp at 115 v ac, noninductive load. **Magnecraft Electric Co.**, 3350T W. Grand Ave., Chicago 51, Ill.

Circle 681 on page 19

Shaft Couplings

in three types

Three precision shaft couplings include 1 in. and ¾-in. diam Oldham couplings, and a disk-type unit. Oldham couplings, consisting of a female floating element and two male elements, have either clamp or pin-type hubs to accommodate any combination of ⅛, 3/16 and ¼-in. shafts. The stainless-steel units tolerate a maximum of 2 deg angular and 1/64-in. lateral shaft misalignment. Disk-type coupling compensates for angular but not lateral misalignment. It is used in



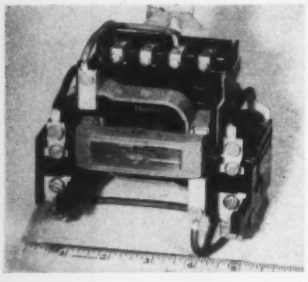
applications where backlash cannot be tolerated, and is available with clamp or pin-type hub. It is rated for maximum torque of 32 oz-in. **Helipot Corp.**, Newport Beach, Calif.

Circle 682 on page 19

Magnetic Motor Starter

has components which snap or slide together

NEMA Size 0 and 1 magnetic motor starter, 42 per cent smaller than previous open forms, is available for application in machine tools, pumps, hoists, blowers, saws, compressors, mixers and packaging machinery. Principal components snap or slide together for quick inspection and maintenance. Overload trip setting can be adjusted to ±15 per cent of nominal heater rating. Improved strongbox coil makes



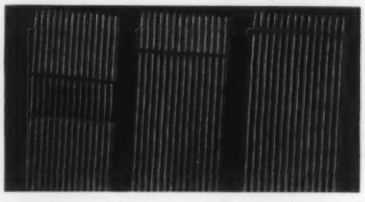
possible the use of a lower rated transformer. Unit can be mounted in any position. Machined air gap, low flux density, and small size magnet contribute to positive dropout. Unit is provided in Size 0, rated up to 5 hp at 440 v, and Size 1, rated for 10 hp at 440 v. Contactor, nonreversing, combination, reversing and multispeed forms are available. **General Electric Co.**, 1 River Rd., Schenectady 5, N.Y.

Circle 683 on page 19

Electrical Cable

in tape form

Tape Cable is flat, ribbonlike electrical cable in which are imbedded flat copper conductors 0.0015-in. thick. Conductors are parallel, accurately positioned, and are surrounded by polyester insulation. Cable has minimum cross-sectional area, low interconductance capacitance, high tear strength, high flex life, and good resistance to chemical attack. Nine sizes are available,



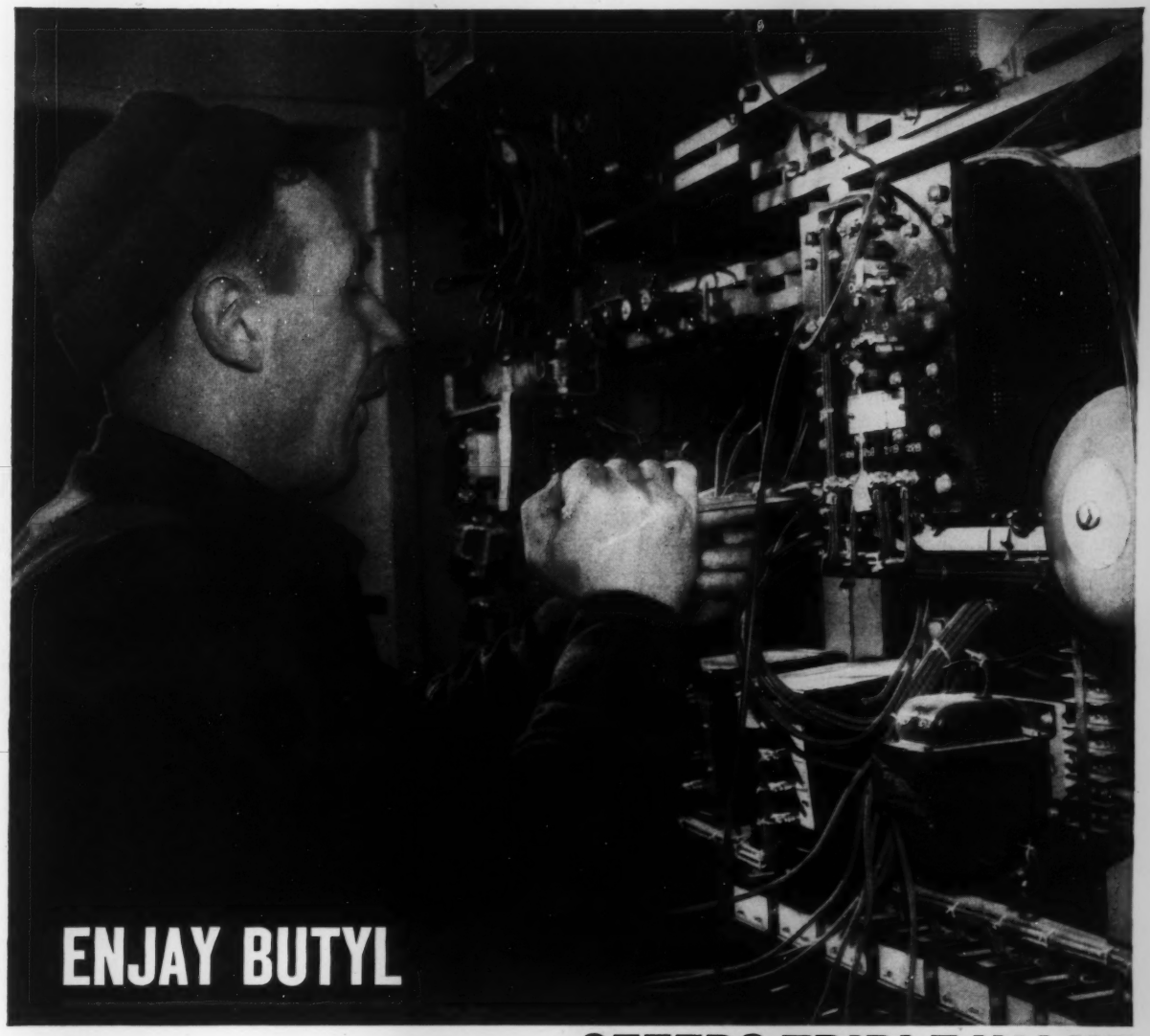
with from 9 to 50 conductors. Cable is furnished in rolls of 1000 ft and can be easily cut to length. **Tape Cable Corp.**, 790 Linden Ave., Rochester 10, N. Y.

Circle 684 on page 19

Miniature Valves

in two and three-way models

These toggle valves can be mounted horizontally, vertically or on a pipe nipple only. They are available in two and three-way models with ⅛ or ¼-in. port sizes. Control



electrical wonder rubber OFFERS TRIPLE VALUE

Performance! Versatility! Economy! In all three, Enjay Butyl is the world's outstanding rubber value. In a wide variety of applications, Enjay Butyl rubber stands *unmatched* in its ability to resist ozone and corona, impact and abrasion, moisture and weathering . . . properties that contribute to the *outstanding* performance of Butyl-made products.

Instrument transformers, underground service cables, high voltage industrial cables . . . in these, and many other electrical applications, Enjay Butyl out-performs and out-lasts *all other* types of rubber, synthetic *or* natural. *Low-in-cost* and *immediately available*, this truly wonder rubber may well be able to cut costs and improve performance in *your* products. For further information, and for expert technical assistance, contact the Enjay Company.

ENJAY

Pioneer in Petrochemicals

ENJAY COMPANY, INC., 15 West 51st Street, New York 19, N. Y.

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ENJAY BUTYL

Enjay Butyl is the greatest rubber value in the world . . . the super-durable rubber with *outstanding* resistance to aging • abrasion • tear • chipping • cracking • ozone and corona • chemicals • gases • heat • cold • sunlight • moisture.

Circle 479 on page 19

(Advertisement)

Cold Heading Cost Savings

Actual Cost Cuts As High As 70%

The most important consideration we can point out to the designer or purchaser of fasteners and small parts is that any part which can be machined from rod stock is also potentially available from the cold heading manufacturer. This technique offers speed of production, without scrap loss, plus superior strength and appearance for low cost and high design efficiency.

The designer need not be restricted to standard fastener sizes when they do not meet the requirements of his application. It is often much less expensive to specify a rivet, nail or screw to meet the task exactly as the application requires, than it is to compromise its function for the sake of "standards." While there is nothing mysterious about the cold heading process, experience has proved it to be of inestimable value for getting maximum quality and output at a minimum cost. While the really spectacular advantages in cost show up in runs of several thousand pieces, we are also able to take care of short run requirements. We welcome and expect manufacturers to come to us for advice and assistance concerning their fastener problems.

Given complete specifications, including a drawing and an idea of the application, we can quickly tell you whether or not it will be advantageous to have your fastener or part JOB-DESIGNED by HASSALL. The remaining important aspect of our service to you is the ability to get into production quickly and make prompt shipment.

Write for a copy of our new booklet, "What the Designer Should Know about Cold Heading".

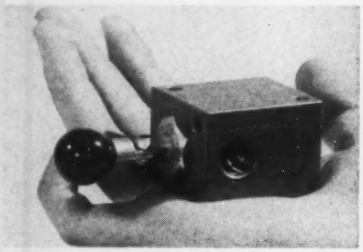
John Hassall, Inc.

P. O. Box 2197

Westbury, Long Island, N. Y.

Circle 480 on page 19

New Parts



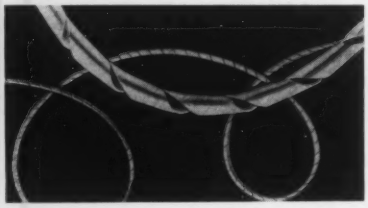
handle swivels 360 deg for easy positioning. Two-way unit can be used normally open or normally closed, and is for use with air, oil or water to 200 psi. Three-way valve is for air use only. It can be connected directly to a spring-return cylinder through use of a pipe nipple or can be mounted separately. **Wm. McLaughlin & Associates,** 123 W. 155th St., Gardena, Calif.

Circle 685 on page 19

Nylon Tubing

is spiral cut

Spiral-cut nylon tubing is available for use such as with bundling, grommet functions or as covers for flexible shafts. Resilience of the nylon spiral provides easy handling and quick snap-on action. Tubing has OD of ⅛, ¼ and ½-in.,



and bundles diameters of ¼, ½ and 1 in. **Polymer Corp. of Pennsylvania,** 2140 Fairmont Ave., Reading, Pa.

Circle 686 on page 19

Limit-Stop Assembly

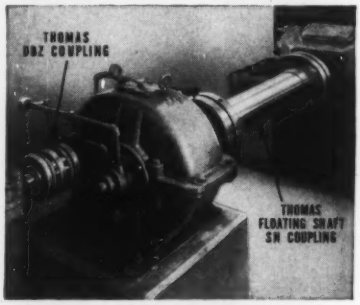
is miniature ten-turn unit

Rotating shaft within this assembly carries an axially moving nut. Shaft is carried in two miniature sealed ball bearings and is assembled with minimum end clearance or play. Adjusting screws strike detent of limit switches. Mechanical stops can be included to protect driven member

THOMAS

FLEXIBLE COUPLINGS

Give You Freedom From Coupling Maintenance



NO LUBRICATION

NO MAINTENANCE

NO WEARING PARTS

Future maintenance costs and shutdowns are eliminated when you install Thomas Flexible Couplings. These all-metal couplings are open for inspection while running.

They will protect your equipment and extend the life of your machines.

Properly installed and operated within rated conditions, Thomas Flexible Couplings should last a lifetime.

UNDER LOAD and MISALIGNMENT ONLY THOMAS FLEXIBLE COUPLINGS OFFER ALL THESE ADVANTAGES.

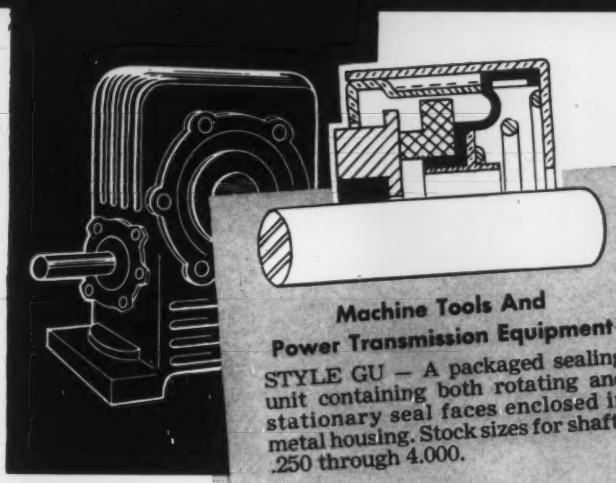
1 Freedom from Backlash Torsional Rigidity
2 Free End Float
3 Smooth Continuous Drive with Constant Rotational Velocity
4 Visual Inspection While in Operation
5 Original Balance for Life
6 No Lubrication
7 No Wearing Parts
8 No Maintenance

Write for Engineering Catalog 51A

THOMAS FLEXIBLE COUPLING CO.

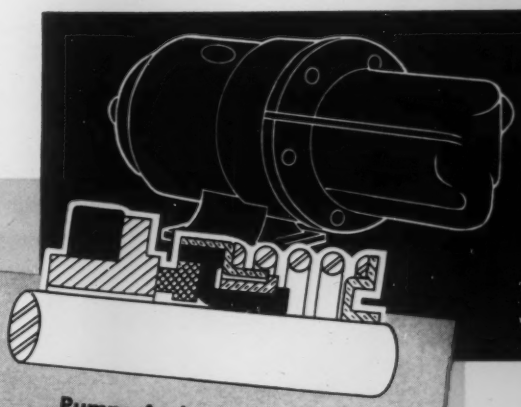
WARREN, PENNSYLVANIA, U.S.A.

Circle 481 on page 19



Machine Tools And Power Transmission Equipment

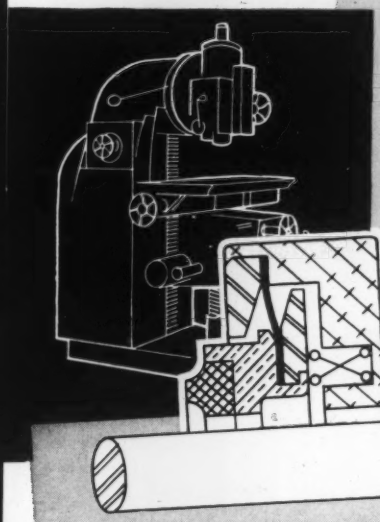
STYLE GU — A packaged sealing unit containing both rotating and stationary seal faces enclosed in metal housing. Stock sizes for shafts .250 through 4.000.



Pumps And Compressors

ROTO-FLEX — Rugged flexibility. Only 3 parts. Single or double units. Stock sizes for shafts .250 through 4.000.

STYLE RFO — A specially designed Roto-flex seal, for installation outside the stuffing box. Stock sizes for shafts .250 through 4.000.



Heavy Machine Tools

STYLE DPC — A high-speed, carbon-faced seal, for more compact installation in heavy industrial machinery. Stock sizes for shafts .250 through 4.000.

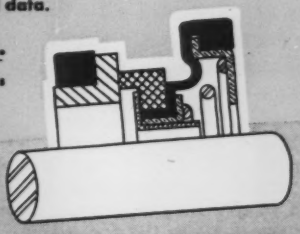
A Complete Line GITS SHAFT SEALS For Every Application

These modern, mechanical, face-type seals are carried in stock — to save you time and money. Write for detailed data.

GITS BROS. MFG. CO.

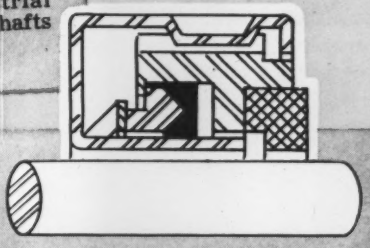
1868-A South Kilbourn Avenue • Chicago 23, Illinois

Specialists In Lubricating Devices And Shaft Seals For Almost Half-A-Century



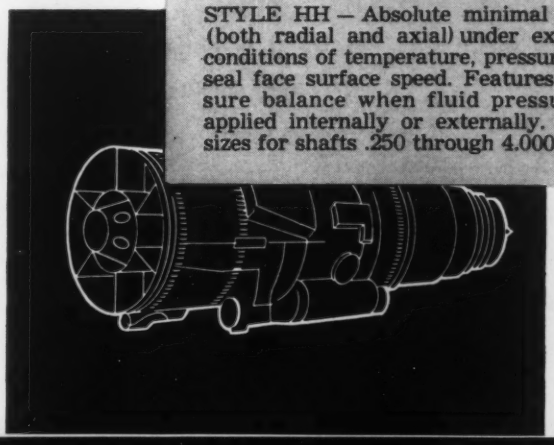
Household Appliances

STYLE SGU—A factory-assembled unit-type seal for the small-budget user. Stock sizes for shafts .250 through 1.000.

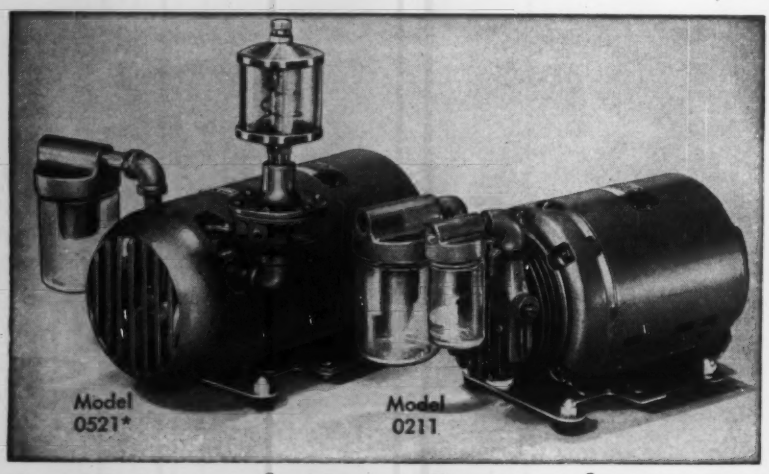


Aircraft Engines And Accessories

STYLE HH — Absolute minimal space (both radial and axial) under extreme conditions of temperature, pressure and seal face surface speed. Features pressure balance when fluid pressure is applied internally or externally. Stock sizes for shafts .250 through 4.000.



Circle 482 on page 19

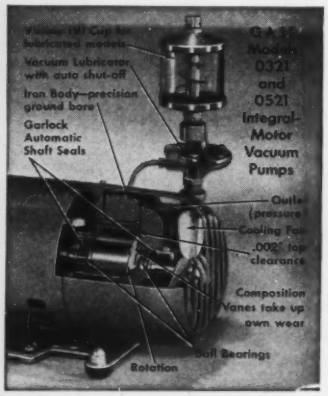


Get 10 Integral-Motor-Pump advantages in two NEW types (three models) of

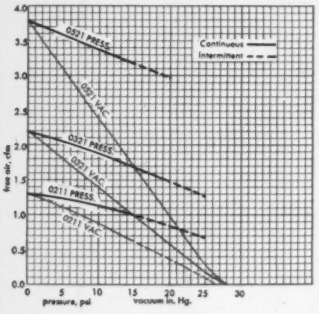
GAST rotary vane AIR PUMPS

Designers seeking a dependable vacuum or pressure source for industrial instruments, vending machines, air gauge circuits, air sampling, laboratory equipment, printing and packaging machinery, etc., will find these *new* Gast Integral-Motor Air Pumps highly advantageous, especially where compactness and portability count. Consider these outstanding features:

1. Latest type G.E. "Form G" motors.
2. More compact than any pump of equal capacity.
3. Total weight reduced ⅓—cuts shipping costs.
4. Motor mounting time and labor eliminated.
5. Simple, trouble-free rotary-vane design.
6. Vanes take up their own wear automatically.
7. Positive displacement, pulseless air delivery.
8. Improved appearance—smoother exterior.
9. Dependable for original equipment; plant use.
10. Forced air fan cooling on Models 0321 & 0521.



Performance-Vacuum & Pressure



Write for new Bulletins V-356 and P-356!
GAST MANUFACTURING CORP.,
P. O. Box 117-P, Benton Harbor, Mich.

*0321 similar in appearance.

Original Equipment Manufacturers for Over 25 Years

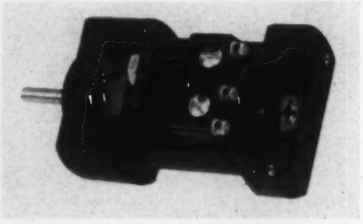
GAST ROTARY

- AIR MOTORS TO 4 H.P.
- COMPRESSORS TO 30 P.S.I.
- VACUUM PUMPS TO 28 IN.

SEE OUR CATALOG IN SWEET'S PRODUCT DESIGN FILE

New Parts

or potentiometer, should electricity stop or circuit fail. Mechanical stops can be adjusted to any position or number of turns from zero to ten. Electrical stop settings can be set from either end to ten



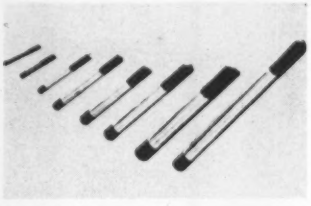
or less turns. Basic configuration is intended for a ten-turn potentiometer, and has a servo-mount pilot and clamping shaft. Driving end of assembly is provided with ⅛-in. shaft. Mounting end is provided with either servo or flange mounting. **United Hydraulics Inc.,** 110 Terrel Court, Dayton 7, O.

Circle 687 on page 19

Alloy-Steel Studs

have tensile strength of over 125,000 psi

Alloy-steel studs, double-drawn and heat-treated to prevent thread distortion and stud failure, have tensile strengths of over 125,000 psi. They are available in quarter-



inch multiple lengths up to 12 in. and in eight diameters from ¼ to 1 in. **Jergens Tool Specialty Co.,** 712 E. 163rd St., Cleveland 10, O.

Circle 688 on page 19

Ac Motors

have outputs to 1 hp

Series 3800 ac motors are designed for induction, torque or hysteresis synchronous applications. Motors are available for input voltages of 26 to 230 v ac, one, two and three-phase; input frequency is from 25 to 400 cycles. Induction units have outputs to 1 hp. Torque mo-

Circle 483 on page 19

From a Sound Blank Comes a Sound Finished Product

One of the best ways to insure top quality in finished circular products is to insist on sound, reliable blanks. You have this assurance when your specifications call for Bethlehem blanks, which are unsurpassed anywhere.

These sturdy steel pieces are made in a two-way mill that combines the steps of forging and rolling. Blanks produced in this mill have uniformity and good grain flow. They are very strong; hence thinner sections can often be used. And their internal structure is so dependable that machining can be done with confidence. There is no hidden trouble lurking beneath the surface of the metal.

Bethlehem forged-and-rolled blanks are widely used in the making of gears, crane and industrial wheels, sheave wheels, flywheels, brake drums, turbine rotors, pipe flanges, and other circular products. They are available in a wide range of sections, and in sizes from 10 to 46 in. OD. Orders can be furnished heat-treated or untreated.

We suggest you get full details from the nearest Bethlehem office. Or write for a copy of Booklet 216, which contains many interesting facts and more than 80 photographs.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation
Export Distributor: Bethlehem Steel Export Corporation

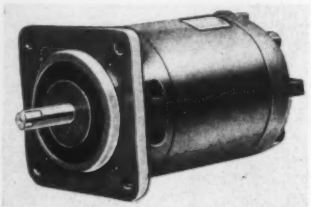
BETHLEHEM STEEL

BETHLEHEM STEEL

Circle 484 on page 19

MEMO TO H. R.
FROM V. L.
Are we using the field engineer from UNION CHAIN? He can help us.
He certainly can. He represents a company that makes all types of steel drive and conveying chain plus sprockets and attachments. His engineering experience is therefore broad. He is familiar with, or able to comprehend, the problems involved in almost any application. And of course since he sells every type of chain he is in a position to make completely unprejudiced recommendations. A good man to cultivate, the Union Chain man.
TRANSMIT POWER
UNION CHAINS
CONVEY MATERIALS
The Union Chain And Manufacturing Company
SANDUSKY, OHIO

New Parts



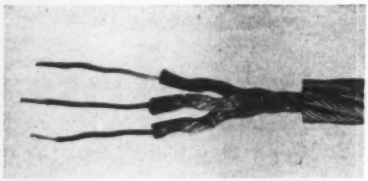
tors have 10 to 200 oz-in. stall torque, and motors for hysteresis synchronous use generate 1/200 to ¼-hp. Units can be wound for single, dual or three speed, and can be supplied self-cooled with internal fan. **Induction Motors Corp.,** 570 Main St., Westbury, N. Y.

Circle 689 on page 19

Wire Rope

transmits signal through center core

SignalKore wire rope, in addition to transmitting force for hoisting and other materials-handling operations, transmits continuous communication instructions through its center core. Copper-wire conductors are imbedded in a fiber core, which is incorporated into the steel-wire rope. Rope can be used with either standard or sound-powered phones. Rope diameters range in size from ¾ to 2 in. Cores for the ¾, 7/8 and 1-in.



diam ropes have two conductors. Ropes with 1⅛ and larger diameters contain three conductors. **American Chain & Cable Co. Inc.,** 929 Connecticut Ave., Bridgeport 2, Conn.

Circle 690 on page 19

Hose Fitting

maintains seal between – 70 and 450 F

Hose is retained between an insert and a collar in a permanent fitting for medium pressure (1500 psi) Teflon hose. Collar diameter is reduced by radial pressure applied

NEW GOLDEN BONDERITE for Aluminum

Uniform color means uniform coatings and uniform efficiency

It's the simplest thing in the world to check on the efficiency of a Golden Bonderite installation. Just look at the color of the aluminum as it comes out of the Bonderite machine. The uniform golden coating looks the same—and it is the same—24 hours a day, seven days a week.

Golden Bonderite sets entirely new standards of efficiency and performance as a paint base for aluminum and its alloys. Operated with the Parker "Reactifier," the Golden Bonderite solution can be used indefinitely, ending the costly necessity of dumping the bath at frequent intervals. Normal chemical replenishment keeps the Golden Bonderite solution in continuous balance.

This ease and certainty of achieving uniformly excellent results means real savings for aluminum fabricators.

It guarantees an effective base for paint.

It breaks the finishing line production bottleneck.

It saves money on chemicals.

It saves money on rejected parts and minimizes field calls because of finish failures.

There are no limitations on the use of new Golden Bonderite. It may be applied by spray or immersion. Treatment cycles can be set to suit production speed and equipment.

Samples of Golden Bonderite-treated aluminum, plus test data, are available for your inspection. Write or call.

How Parker "Reactifier" Works

In conventional surface treatments of aluminum, work passing through the solution causes a buildup of impurities. As impurities increase, solution efficiency decreases until there's nothing to do but dump the bath and start over.

The Parker "Reactifier" removes these impurities as fast as they are formed in the Golden Bonderite solution. Constant circulation of the Golden Bonderite through the exclusive "Reactifier" means a balanced, efficient solution that can be used indefinitely.

Write for Bulletin in COLOR!

Get your copy of the descriptive bulletin on Golden Bonderite and its companion, Green Bonderite, for aluminum. It's new!

Since 1914—leader in the field

PARKER RUST PROOF COMPANY
2193 E. MILWAUKEE, DETROIT 11, MICHIGAN

BONDERITE	BONDERITE and BONDERLUBE	PARCO COMPOUND	PARCO LUBRITE	TROPICAL
corrosion resistant paint base	aids in cold forming of metals	rust resistant	wear resistant for friction surfaces	heavy duty maintenance paints since 1883

**Bonderite, Bonderlube, Parco, Parco Lubrite, —Reg. U.S. Pat. Off.*

get pumping efficiency

...with I-R motorpumps

Here is a line of efficient, dependable centrifugal pumps that can add to the overall performance of the equipment you manufacture . . . Ingersoll-Rand Motorpumps — available in the widest range of types and sizes — are made to stand up under the most severe service; will provide the best in low-cost, low-maintenance operation.

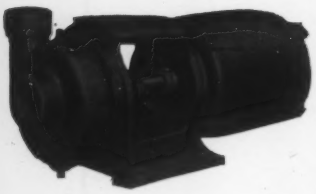
Send for your copy of literature that contains complete performance and installation data.

MOTORPUMP

by

Ingersoll-Rand

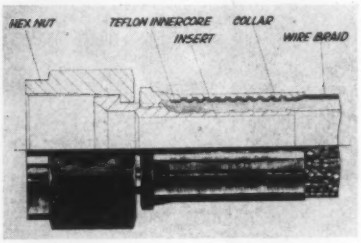
11 Broadway, New York 4, N. Y.



9 647

New Parts

along its length, working plastic inner core and braid forward toward hex nut. Positive lock results between braid and fitting, and between inner core, braid and insert. Seal does not leak after extreme temperature cycling between − 70 and 450 F. Configurations available include straight fittings, 45 and



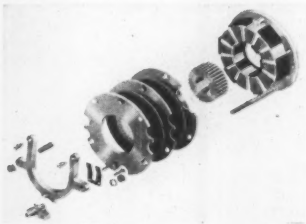
90-deg elbows. Sizes range from 3/16 to 1¼ in. hose diameter. Lines equipped with the fittings meet MIL-H-25579 (USAF). **Titeflex Inc.,** Hendee St., Springfield 4, Mass.

Circle 691 on page 19

Electric Brake

fits any NEMA C face motor

Series E electric disk brake fits any standard NEMA C face motor. Taper lock bushing assures positive pinion retention and affords simplifier motor mounting without disassembly. Air gap limiter provides protection against coil burn-



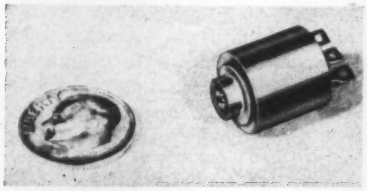
out. Brake is rated from 3 to 260 lb-ft. **Safety Industries Inc.,** Star-Kimble Industrial Motor Div., Hamden, Conn.

Circle 692 on page 19

Miniature Potentiometer

for applications to 125 C

Mite-E-Mite miniature potentiometer can be solder-mounted, permitting maximum resistance to vibration. High hermetic resistance is provided by O-ring seal and



glass-sealed header. Unit weighs 10 grams and has applications where size and weight are limiting factors. **San Fernando Electric Mfg. Co.**, General Scientific Div., San Fernando, Calif.

Circle 693 on page 19

Power Transmission Parts

include molded nylon units and metal adapters

Molded-nylon spur gears, thrust washers and metal adapters for nylon sleeve bearings have been added to a line of nylon power-transmission parts. Gears are available in 48 pitch, 1/8-in. face by 14½ deg pressure angle and 32 pitch, 3/16-in. face by 14½ deg pressure angle. Both have standard stock bore sizes ranging from 3/32 to 3/8-in. Thrust washers of 1/16-in. molded stock are available in sizes from 1/8-in. ID by 3/8-in. OD to 1½ in. ID by 3 in. OD. Metal adapters for nylon sleeve bearings have OD machined to fit oversize bearing housings. Adapters are available in steel, brass, bronze and aluminum. **Climax Metal Products Co.**, 863 E. 140th St., Cleveland 10, O.

Circle 694 on page 19

Zippered Tubing

for multiconductor wiring use

Zippertubing encases, identifies and protects multiconductor wiring in aircraft, electronic or electrical industries. Tubing can be perforated to allow branch-outs or permit moisture to escape, or lined

WHY *Cambridge*

WOVEN WIRE BELTS

mean low cost, continuous processing

By providing belt-to-belt movement at controlled speeds, woven wire conveyor belts eliminate batch handling, increase product uniformity and production capacity in all types of manufacturing. No matter what you're processing . . . metal parts, food products, chemicals, plastics, ceramics, glass . . . wet or dry, hot or cold . . . you can cut operating expenses all along the line by combining movement with processing. EXAMPLE:

Continuous Heat Treating

MOVING BELT carries a stream of brass light bulb ferrules through furnace for continuous, uniform annealing at 1400° F.

OPEN MESH of Cambridge belt allows free circulation of heat around the load so that hot spots are eliminated. Open mesh construction also permits rapid drainage in wet processes such as quenching and washing.

ALL-METAL BELT withstands heat up to 2100°F. (as in copper brazing) without damage, provides lasting strength because there are no seams, lacers or fasteners to break or wear.

SPECIAL RAISED EDGES hold parts on belt, are typical of variety of side and surface attachments available to hold your product during flat or inclined movement.

Regardless of your industry . . . metal-working, food, chemical, glass or ceramic . . . you'll find combined movement and processing practical and economical in machines for your own operation or for resale. Cambridge Woven Wire Conveyor Belts are made in any size, mesh or weave, from any metal or alloy to do the job you want . . . hot or cold, wet or dry. Call your Cambridge Field Engineer to discuss how you can cut costs by continuous operation. Look under "Belting, Mechanical" in the Yellow Pages . . . or write for FREE 130-PAGE REFERENCE MANUAL.

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WIRE CLOTH | METAL CONVEYOR BELTS | SPECIAL METAL FABRICATIONS

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OFFICES IN PRINCIPAL INDUSTRIAL CITIES

Circle 488 on page 19

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Provides synchronized printing and developing speed, with full stop and reverse control.

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Handles cut sheets or roll stock up to 44 in. wide in any length.

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Ruggedly built of jig-drilled aluminum castings.

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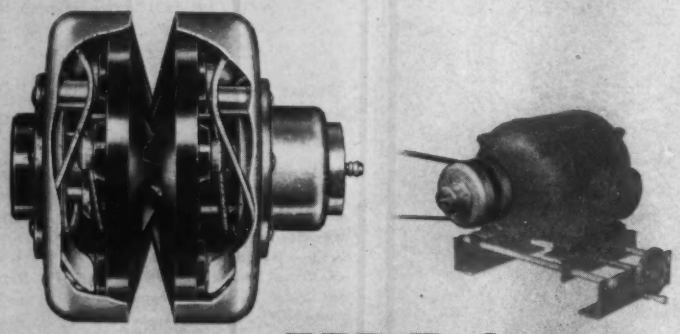
Circle 489 on page 19

striving for SIMPLICITY?



here's how HI-LO *helps*

Design-wise, HI-LO automatic variable speed pulleys help you reduce complex design problems. Functionally, they're first choice of many design engineers for a wide range of applications. The simple, positive action of cam followers on cams is the mechanical action that takes place in maintaining the pitch diameter setting regardless of load—an exclusive feature of HI-LO pulleys. Springs in HI-LO pulleys are not driving members as in most spring-loaded pulleys, but serve primarily to keep the pulley faces in contact with the belt.

For *FREE* technical manuals with diagrams, descriptions of applications and other power transmission data, write:

Equipment Engineering Company

2855 Columbus Ave., Minneapolis, Minnesota

New Parts

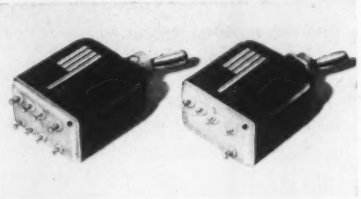
on inside to protect wires against heat or cold. It is available with 0.020 and 0.040-in. wall thicknesses in nine colors, including black and clear plastic. **Zippertubing Co.**, 5333 S. Sepulveda Blvd., Culver City, Calif.

Circle 695 on page 19

Automatic-Disconnect Switch

is magnetically held to prevent continuity errors

Automatic-disconnect switch is magnetically held and automatically disarmed when energizing



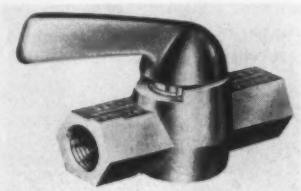
voltage drops between 13 and 5 v. Unit is fail safe since solenoid will not pull switch closed. Unit withstands vibration frequencies to 500 cps at 10 *g*. Switch occupies less than 2.5 cu in. and weighs 4 oz. Design eliminates errors of circuit continuity resulting from residual fields after power failure. Switch is available in single and double-pole models in corrosion-resistant casings. **Lear Inc.**, 110 Ionia Ave. N.W., Grand Rapids, Mich.

Circle 696 on page 19

Plug Valves

in ¼, ½ and ¾-in pipe sizes

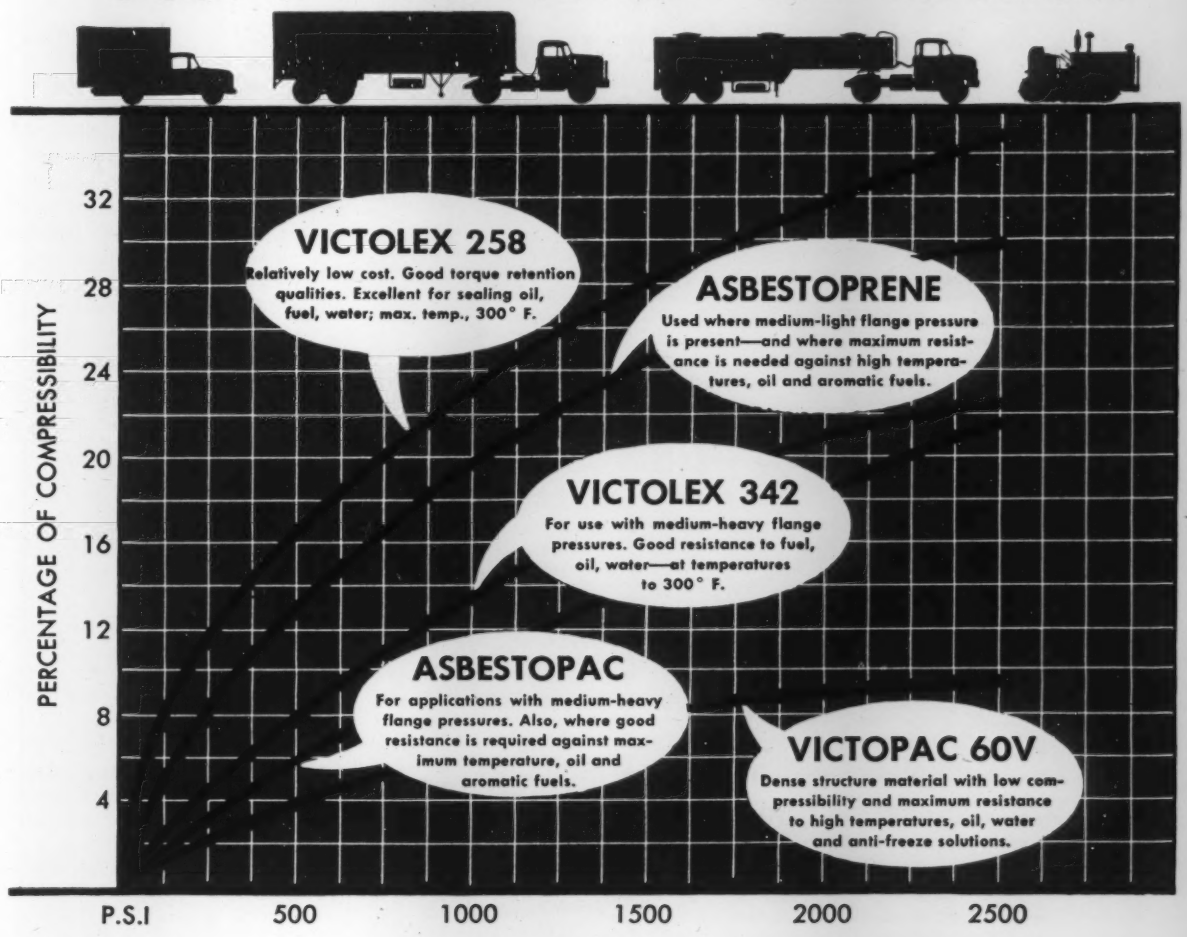
These plug valves are operated by handles that open and close against pressure with no effort, and are available in ¼, ½ and ¾-in. pipe sizes. O-ring flow seal and O-rings at top and bottom prevent



external leakage. Valve is full ported and allows straight-through flow passage in open posi-

VICTOR

"Soft" PACKINGS FOR HEAVY-DUTY INDUSTRIES


PERCENTAGE OF COMPRESSIBILITY
32
28
24
20
16
12
8
4
P.S.I
500
1000
1500
2000
2500
VICTOLEX 258
Relatively low cost. Good torque retention qualities. Excellent for sealing oil, fuel, water; max. temp., 300° F.
ASBESTOPRENE
Used where medium-light flange pressure is present—and where maximum resistance is needed against high temperatures, oil and aromatic fuels.
VICTOLEX 342
For use with medium-heavy flange pressures. Good resistance to fuel, oil, water—at temperatures to 300° F.
ASBESTOPAC
For applications with medium-heavy flange pressures. Also, where good resistance is required against maximum temperature, oil and aromatic fuels.
VICTOPAC 60V
Dense structure material with low compressibility and maximum resistance to high temperatures, oil, water and anti-freeze solutions.

Full range of synthetic packings

The five Victor "soft" packings plotted on the comparative compressibility chart answer many problems for automotive sealing engineers. Each packing is made of the best materials for coping with problems inherent in specific applications. Each has the right density and degree of compressibility to meet varying flange pressures, temperatures and the penetration of water, oils and other fluids. Each packing conforms to SAE-ASTM specifications.

Complete technical information about these packings and their uses is available from your Victor Field Engineer. If you do not know where to reach him, write Victor Mfg. & Gasket Co., P. O. Box 1333, Chicago 90, Ill.

VICTOR

Sealing Products *Exclusively*

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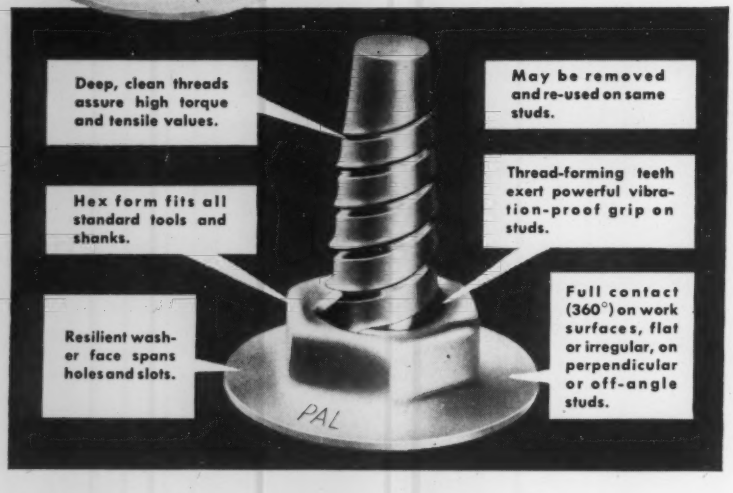
Circle 491 on page 19

New! PALNUT®
SELF-THREADING NUTS

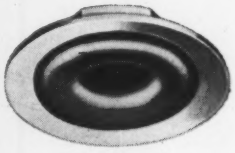
Make their own threads on studs — easily, quickly


Deep, clean threads assure high torque and tensile values.
Hex form fits all standard tools and shanks.
Resilient washer face spans holes and slots.
May be removed and re-used on same studs.
Thread-forming teeth exert powerful vibration-proof grip on studs.
Full contact (360°) on work surfaces, flat or irregular, on perpendicular or off-angle studs.
PAL

Ideal for Nameplates — Ornaments — Moldings with die-cast or cold-forged studs

Now . . . low-cost, plain studs become strong, vibration-proof threaded assemblies by simply fastening with the new PALNUT Self-threading Nuts. You eliminate the high cost of threaded studs—your fastening operation does the thread-cutting while tightening. No special tools needed—high-speed assembly is obtained with standard tools and methods.

PALNUT Self-threading Nuts are made of spring-tempered steel, comprising a thread-cutting lock nut and flat washer in one piece. Parts are pulled up tight with a resilient spring locking action that will not loosen in service. Available in sizes for 1/8", 3/16" and 1/4" unthreaded studs. Write for free samples and descriptive literature.



Also available with "bonded-in" plastisol compound to seal out water and dust.

THE PALNUT COMPANY, 75 Glen Road, Mountainside, N. J.
Subsidiary of United-Carr Fastener Corporation

PALNUT® LOCK NUTS FASTENERS PAL®

Quick, secure fastening at low cost

Circle 492 on page 19

New Parts

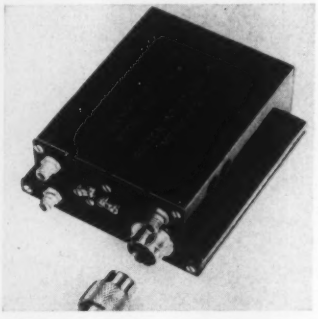
tion. The 1/4-in. size is available in stainless steel with aluminum handle. Other sizes are brass. **Circle Seal Products Co. Inc.**, 2181 E. Foothill Blvd., Pasadena, Calif.

Circle 697 on page 19

Amplifier

is miniature airborne unit

Model F-418 miniature amplifier is for use in missiles, aircraft and other structures where size, weight, power consumption and vibration are important factors. Unit incorporates subminiature tubes selected for low microphonics. Ungrounded filaments also minimize noise. Amplifier has provision for both fixed and variable gains, from 10.2 to 99.5 for variable and 10 to 100 for fixed gains. Amplifier permits adjustment of system gain of accelerometer, amplifier and filter so that full-scale gain of system can be adjusted within necessary tolerances. **Gulton Industries Inc.**, 212 Durham Ave., Metuchen, N. J.

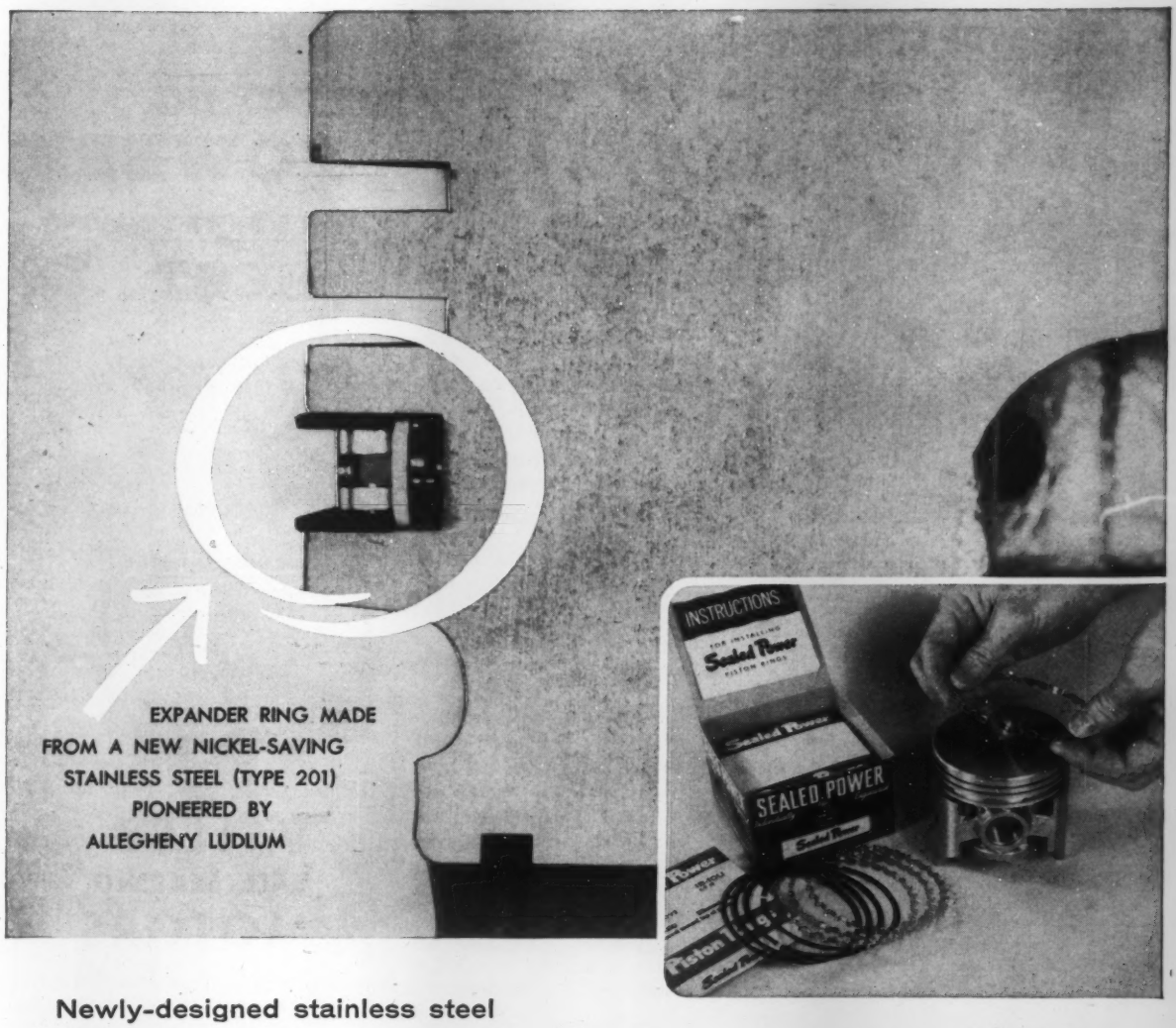


Circle 698 on page 19

Variable Speed Reducer

is motorized reversible unit

Zero-Max reversible variable speed reducer provides instant reversing, while running or stopped, without motor reversal and with accurate speed repetition. Basic unit consists of a reversible variable speed reducer built onto a 48-frame motor which drives reducer through 1:1 helical gears in reducer housing. Unit is reversed by a lever at the top rear of the reducer housing. Reversing motor does not reverse output shaft. Output speed can be set from 0 to 400



Newly-designed stainless steel

OIL RING ASSEMBLY gives auto drivers 3-WAY ADVANTAGE

BETTER OIL ECONOMY

BETTER ENGINE PROTECTION

LONGER ENGINE LIFE

Oil rings do a very demanding job in an automobile engine. They control the amount of lubricant allowed to pass up to the compression rings and cylinder walls. In modern cars, with higher compression ratios, the tension of the oil ring expanders has had to be increased—and that's where Allegheny Type 201 stainless offers advantages.

Engine operating temperatures have virtually no effect on this new stainless alloy. It maintains constant tension whether the engine is hot or cold, permitting most efficient design for maximum flow of lubricant when friction is greatest, and less flow when the engine is warmed up and requires less. Formerly, carbon steel expander rings suffered a tension drop when heated to engine operating temperature. Then under heat they took a permanent set, which caused the loss of "cold tension." Allegheny 201 also has ended the problem of expander breakage due to the corrosive action of engine deposits.

This success story is just one of many being written with the new 200-series of low-nickel Allegheny Stainless Steels. Fabricating methods are virtually the same as with the higher-nickel 300-series, but you'll find some advantage in cost, and much greater availability in times of nickel shortage. • If these new steels seem to fit into your manufacturing or service picture, give us a call. *Allegheny Ludlum Steel Corporation, Oliver Bldg., Pittsburgh 22, Pa.* WSW 6528

WRITE for a copy of our "Technical Horizons" bulletin on the Allegheny 200-Series stainless steels.

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Make it BETTER—and LONGER LASTING—with

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Warehouse stocks carried by all Ryerson steel plants

Circle 493 on page 19

. . . PUT UP THE WIND SHIELD, NELLIE

When the going got dusty back in 1907, Nellie had to put up the "wind shield" on this early Pope-Toledo. Mamma was too busy with spark, throttle, mixture, lubricator, cone clutch, progressive shift, bulb horn, two-hand steering and hand-and-foot brakes to do that too. And can you imagine what that gritty, billowing dust did to the EXPOSED *gears*, protected only by some sticky, poor-grade grease? No wonder tolerances were generous — and gear life short!

Into this pioneering atmosphere plunged John Christensen and Soren Sorensen, to start in the gear business. The problems that faced them then were different than those we face today, but we still adhere religiously to their formula for meeting them — do the best job possible every time, and be sure it's done a little better than anyone did it before. We think that's the main reason we've built up such a satisfied list of steady customers over the past 50 years. We'd like to add *you* to this list too — why not give us an opportunity on your next custom gear order?

THE CINCINNATI GEAR CO.
CINCINNATI 27, OHIO
Fifty Years of "Gears — Good Gears Only"

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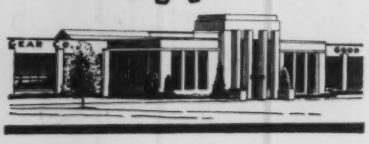
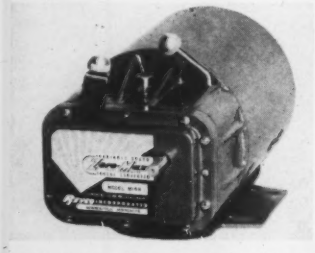


Circle 494 on page 19

New Parts



rpm. Speed setting can be changed while unit is operating in either direction or in neutral. The motorized reducer is available in models delivering 10, 15 and 20 lb-in. constant torque through entire speed range to zero rpm. **Revco Inc.**, 1900 Lyndale Ave. South, Minneapolis 5, Minn.

Circle 699 on page 19

Miniature Relay

uses wedge-action switching principle

Mark II relay is a six-pole, double-throw, hermetically sealed unit which meets MIL-R-5757C and MIL-R-25018. It uses wedge action to achieve positive contact in both energized and de-energized conditions. Action involves constantly increasing contact pressure during overtravel period after initial engagement. It also removes contaminants from contact surfaces, reducing resistance to

micro-level currents, and providing excellent shock and vibration resistance. Operating ambient temperature range is − 65 to 200 C. It switches currents reliably from dry-circuit levels to 2 amp. **Electro Tec Corp.**, South Hackensack, N. J.

Circle 700 on page 19

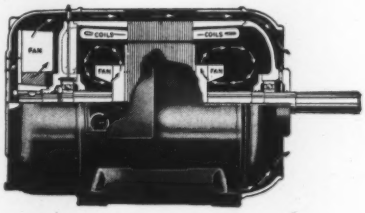
Air-Hydraulic Cylinder

has external threads on cylinder barrel

Cylinder for air or hydraulic service has high strength and re-

ELECTRIC POWER
AT IT'S MONEY SAVING BEST . . !

AIR COOLED



VALLEY
BALL BEARING
MOTORS

This completely enclosed but... air cooled motor is of the latest design—no foreign matter can penetrate the windings. Its ball bearings and stator core are kept cool by 3 fans which transfer the heat to the frame and end bells — cooling the motor completely — and remember a cool motor runs longer.

Other Types of Valley Motors

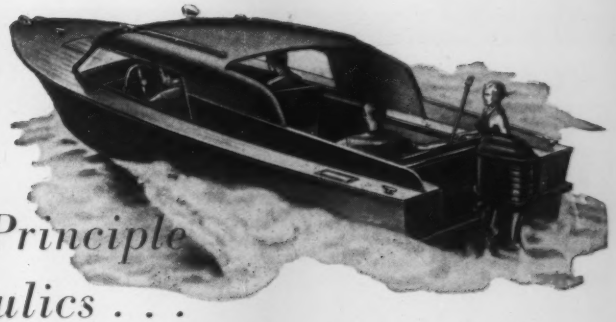
Type SN polyphase, high torque, constant speed, continuous duty, squirrel cage induction.

Type AN single phase, constant speed, continuous duty, repulsion start, induction run.

Write for Descriptive Literature.

VALLEY
ELECTRIC CORPORATION
4221 FOREST PARK BLVD. • ST. LOUIS 8, MO.

Circle 495 on page 19



The "Outboard Motor" Principle Applied to Hydraulics . . .

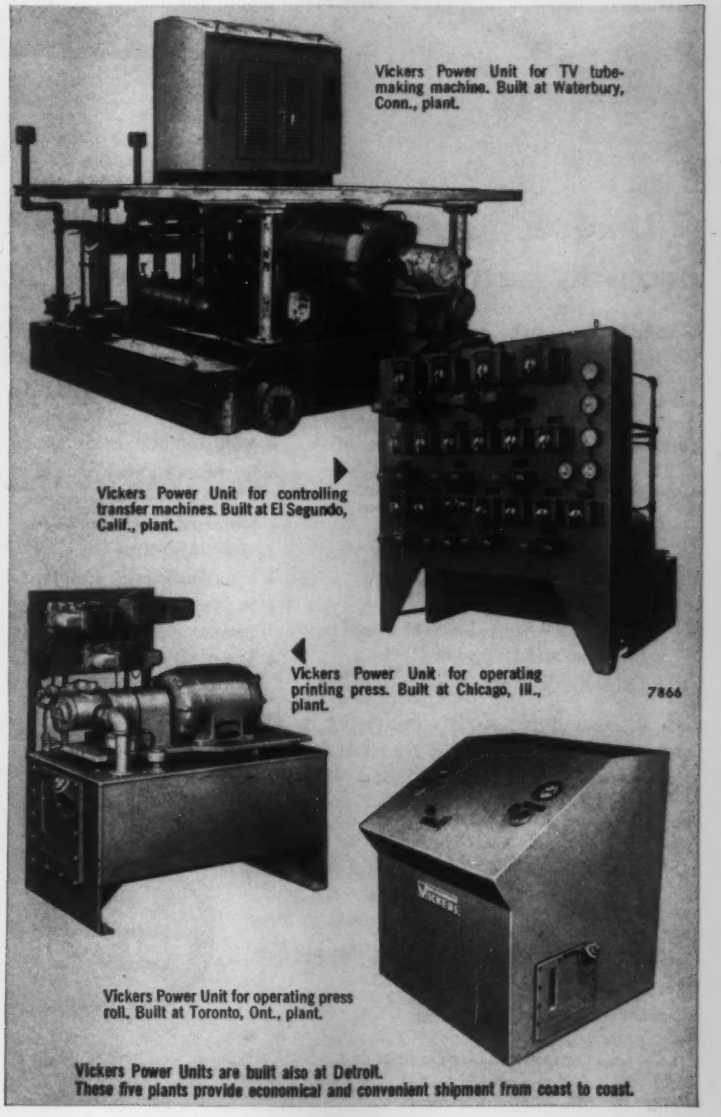
VICKERS® "Packaged" Hydraulic Power Units Are Compact, Convenient and Economical

The outboard motor is popular because it is a complete, self contained power package . . . quick and easy to apply.

Vickers Custom-Built Power Units provide a comparable packaged system for the hydraulics of any particular machine or job. Built to the exact needs, it is compact, efficient, and very quick and easy to apply.

All necessary pumps, valves, intermediate piping, motors, controls, oil reservoir, oil filters, air cleaners, oil level gauges, fittings, etc. are included, as well as electronic components if used.

You are assured dependable performance. Design is improved and simplified, time and cost of installation are reduced, appearance is better, servicing is easy. Each unit is pretested at the factory and is ready for immediate operation. Vickers undivided responsibility for the entire hydraulic control system is important to both the machine builder and his customer. Write for Bulletin 52-45.


Vickers Power Unit for TV tube-making machine. Built at Waterbury, Conn., plant.
Vickers Power Unit for controlling transfer machines. Built at El Segundo, Calif., plant.
Vickers Power Unit for operating printing press. Built at Chicago, Ill., plant.
7866
Vickers Power Unit for operating press roll. Built at Toronto, Ont., plant.
Vickers Power Units are built also at Detroit.
These five plants provide economical and convenient shipment from coast to coast.

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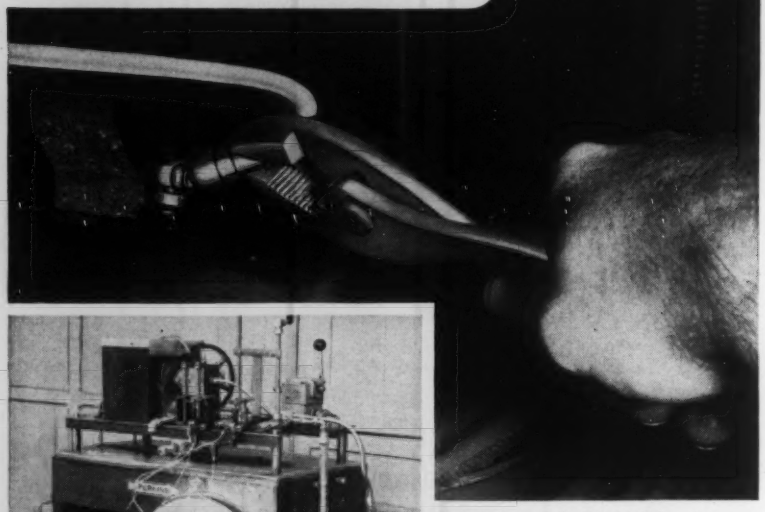
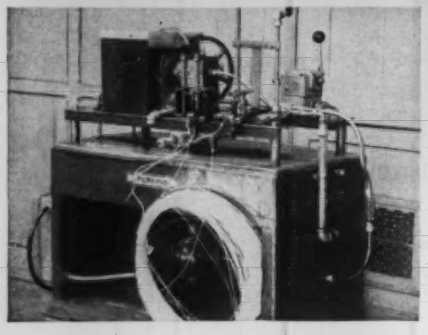
ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

Circle 496 on page 19

NYLAFLOW® PRESSURE TUBING





Installation of flexible Nylaflow is convenient, economical, low cost: it can be used with standard metallic fittings.

(*Left*) Nylaflow undergoes a quick burst test—one of the in-process quality controls used in manufacture.

Unique characteristics of *NYLAFLOW* provide better performance, lower costs

Nylaflow is a tough, resilient polyamide tubing. Its unusual combination of characteristics—different from any other tubing—has increased its use in a growing number of industries and applications. The superior performance of Nylaflow Pressure Tubing has proved advantageous in the following applications:

- Lubrication lines
- Hydraulic lines
- Air or vacuum lines
- Oil and fuel lines
- Beverage and syrup lines
- Caustic or solvent lines

***NYLAFLOW* gives you:**

- High burst strength at low cost
- Outstandingly long flex and vibrational life
- Abrasion and crush resistance
- Resistance to solvents, oils, alkalis, hydraulic fluids
- Non-toxic, non-corrosive, fungus resistant properties
- Installation with standard fittings
- Flexibility—eliminating prebending
- Form stability—can be permanently bent with heat

Nylaflow Pressure Tubing is available in short time burst ratings of 1000 psi.—Type T, and 2500 psi.—Type H. It is manufactured to conform with Polymer Specification NYT-800. For latest data on design and performance possibilities write today for Nylaflow Bulletin.

THE POLYMER CORPORATION OF PENNA.

Reading, Pa.

Export: Polypenco, Inc., Reading, Pa., U.S.A.

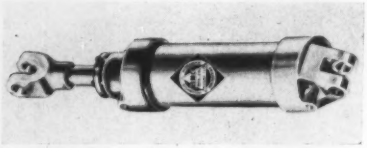
Nylon, Teflon*, NYLAFLOW and NYLATRON® GS

*DU PONT TRADEMARK

POLYPENCO®

New Parts

sistance to external damage. External threads on cylinder barrel, with internal threads on heads, prevent cylinder breathing under high pressures. Outside threads on cylinder permit full use of internal honed tubing surface, providing



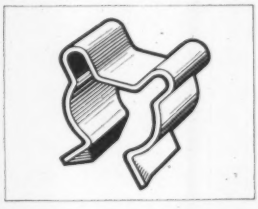
long stroke or short over-all length of cylinder. Cylinder heads are cast steel, and are O-ring sealed. Barrels are heavy-wall, precision-honed, seamless-steel tubing. **Remco Mfg. Co.**, Petaluma, Calif.

Circle 701 on page 19

Spring-Steel Clip

for radio and television control knobs

New one-piece Speed Clip secures radio and television control knobs to tuning shafts. Inserted by hand into the knob recess with slight compression, fastener centers itself and locks firmly in place. Tensioning loops at top of clip provide evenly distributed bearing surfaces, minimizing wear on knob. Knob with assembled fastener is



thrust over D-shaped shaft where it is held firmly under live spring tension. Slight pressure is needed to remove knob from shaft. **Tinnerman Products Inc.**, P.O. Box 6688, Cleveland 1, O.

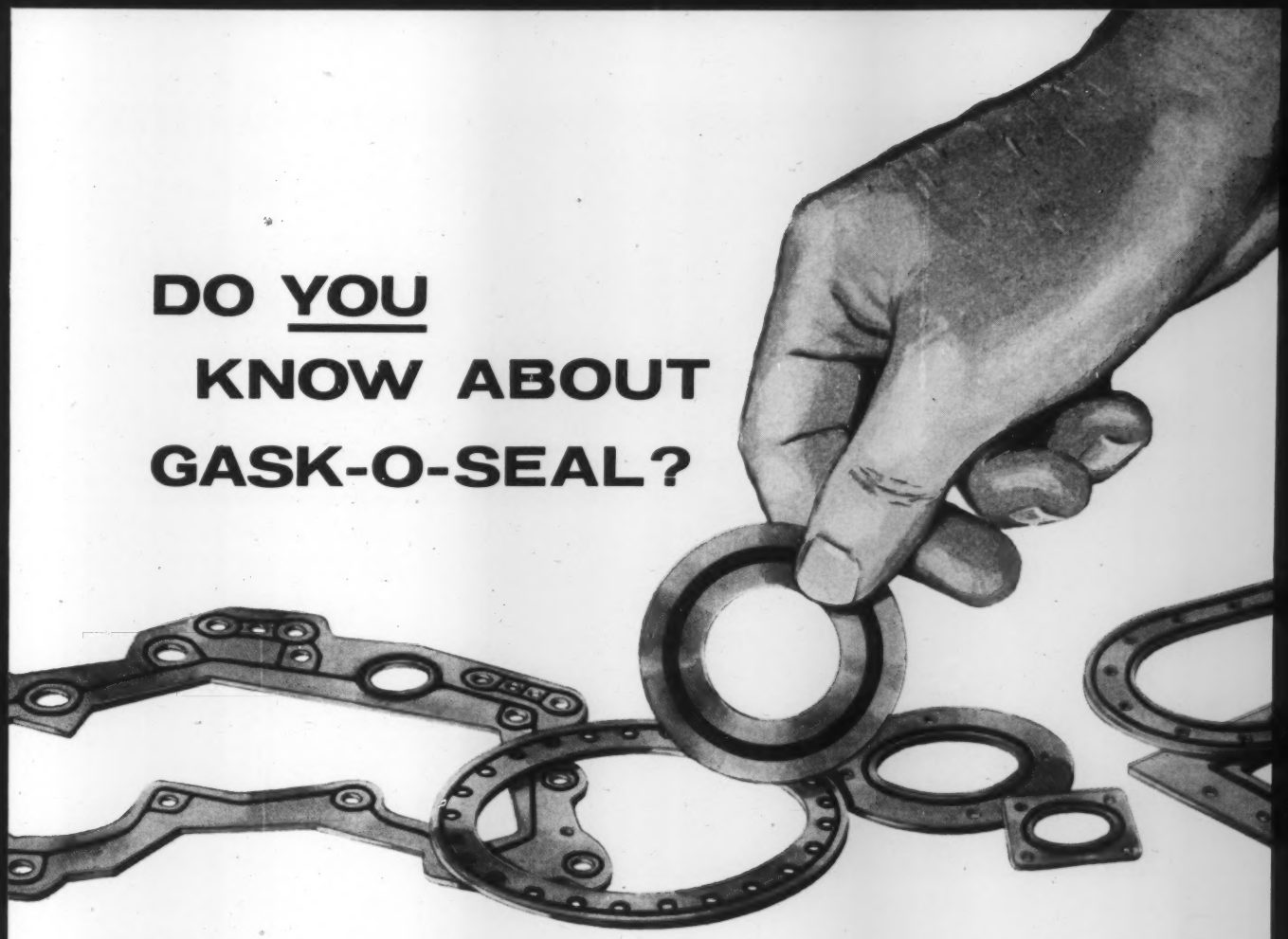
Circle 702 on page 19

Shaft-Position Encoder

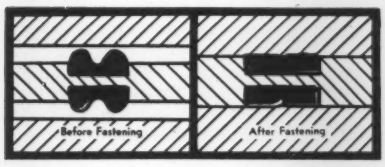
has 3-minute angular accuracy

Type RD-13 Digisyn is a high-precision photoelectric shaft-position encoder which provides angular position data in cyclic binary code to an accuracy of 13 digits, or bet-

DO YOU KNOW ABOUT GASK-O-SEAL?



The static seal that can not blow out!



The above diagram is "typical" only. Gask-O-Seals are also made with one-side seals.

If you do not know about Gask-O-Seals look at these facts:

- ✔ Gask-O-Seals will seal practically any processable fluid . . .
- ✔ Gask-O-Seals can be re-used . . .
- ✔ Gask-O-Seals will seal at low or high pressures, vacuum or positive . . .
- ✔ Gask-O-Seals are available as standards and as specials in almost any configuration or to meet special requirements.

They are recommended for flanges, gear boxes, transfer cases . . . *any* place where truly efficient static seals are needed.

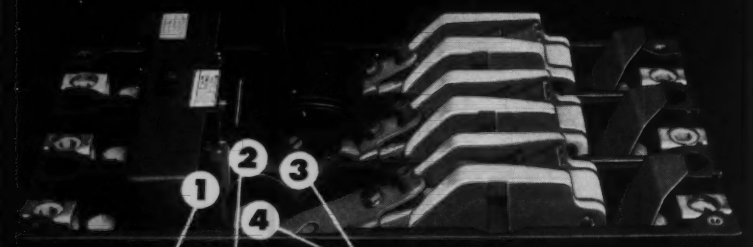
Note: A recent development of the Gask-O-Seal principle indicates effective sealing in the temperature ranges of −400° to +1000° for specific applications.

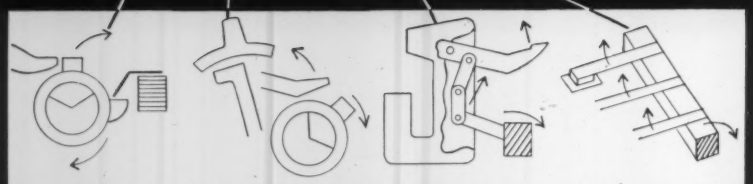
"—the O-Seal family:
Lock-O-Seal®
Gask-O-Seal®
Stat-O-Seal®
Bolt-O-Seal®
Riv-O-Seal®
Banj-O-Seal®
Termin-O-Seal®

FRANKLIN C. WOLFE CO.
Culver City, California
"sealing design specialists"
A DIVISION OF Parker APPLIANCE COMPANY
Hydraulic and fluid system components

Circle 498 on page 19

only
circuit breakers prevent
fault single-phasing





1. Short circuit or overload involving any conductor trips lever, rotates common trip bar.

2. Rotating trip bar releases the latch arm —which rapidly moves upward.

3. Latch release activates quick-trip linkage, pivoting common breaker bar.

4. All breaker arms yoked to common bar... fault in one line trips all 3 poles.

THE ABOVE ACTION COMPLETELY CLEARS THE CIRCUIT IN AS LITTLE AS ⅜ CYCLE.

Westinghouse AB breakers
trip ALL THREE poles
on any circuit fault

YOU CAN BE SURE...IF IT'S
Westinghouse

WESTINGHOUSE ELECTRIC CORP. BOX 868, PITTSBURGH 30, PA.

MULTI-PHASE CIRCUITS REQUIRE MULTI-PROTECTION

by H. D. Dorfman
Westinghouse Electric Corporation

In 3-phase operation, one phase may sometimes be faulted to ground without directly affecting the other two lines. This can be dangerous to personnel—and intolerably expensive in damage to 3-phase equipment continuing to operate. Such single-phasing virtually doubles the effective amperage, dooming motors not immediately taken out of service. For example:

Single-Phasing Burns Out Motor

Case 48SW3: Motor, rated at 9 amp, 3 phase and demanding 7.5 amp to power a blower, was on a circuit protected by three 20-amp fuses. One line faulted to ground, blowing its protective fuse. The motor continued running on the two unfaulted lines—single-phasing at an estimated 13.5 amp. This load was not enough to blow the remaining fuses and improperly applied overload relays did not act in time.

Result: Burned-out motor.

Single-Phasing Creates Hazard

Case 52PC5: Machine motor rated 10 hp, 440 volt, 3 phase, was controlled by a combination reversing starter having 17.5 amp time-delay fuses. Evidently, one fuse blew to clear a phase-to-ground fault. Soon after, the unsuspecting operator attempted to stop the machine by "plugging", in an emergency. Due to the single-phase condition, braking was not achieved.

Result: Accident.

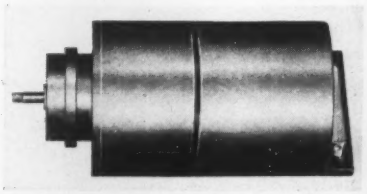
Other examples can be cited, illustrating that even dual-element, time-delay fuses do not always prevent harsh treatment of motors and controls, when fault single-phasing occurs.

AB Breakers Prevent Such Losses

Any LOAD-side fault causes simultaneous tripping of all three breaker poles, immediately isolating the troubled section. As soon as the fault is removed, power can be quickly restored by simply flipping the breaker handle.

Properly made and tested breakers will always operate at the load for which they are rated. Calibrations of Westinghouse breakers are not altered by time or by load cycles. They require no maintenance, being designed to outlive circuits in which they are placed. Time saving, greater reliability and greater accuracy more than offset the sometimes greater initial investment as compared to other circuit protectors.

J-30260



ter than three minutes of arc. Unit consists of a glass disk coded by opaque and transparent segments, flash lamp to illuminate a radius of code disk, multielement photosensitive detector to detect presence or absence of illumination, and 13-channel transistor preamplifier. Each channel is encapsulated separately and is easily replaceable. Unit meets applicable portions of MIL-E-4158A. Typical applications include automatic tracking, servo, automatic machine control and navigation systems. **Adcon Corp.**, 1117 Commonwealth Ave., Boston 15, Mass.

Circle 703 on page 19

High-Pressure Seals

are miniature units for pushbutton switches

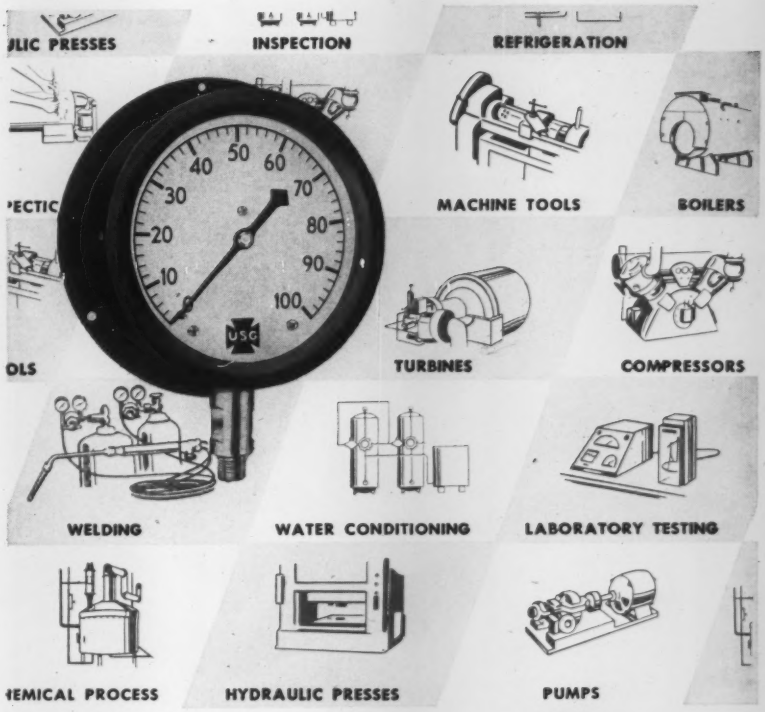
Hexseal Series N-3000 high-pressure seals for standard pushbutton switches replace switch lock nuts on exterior of panel, and serve as both seal and lock nut. High-pressure sealing is maintained by a gasket rib which seats firmly against panel to keep out moisture, dust or combustible vapors. Seals are silicone rubber, chemically bonded to nut. Flexible from −120 to 500 F, they are unaffected by exposure to sun and weather, and are impervious to salt water, acids and ozone. Standard thread sizes are 15/32-32 and ½-32. **Automatic & Precision Mfg. Co.**, 252 Hawthorne Ave., Yonkers, N. Y.

Circle 704 on page 19

Epoxy Glass Laminate

for applications where black material is desired

Micaply Grade EGM-B epoxy glass laminate for printed circuitry is available in black for applications where black material is desired. Standard thicknesses range from 0.032 through 0.5-in. Black lami-



industry buys more USG gauges than any other make

HERE'S WHY

- Practically all industrial gauge requirements can be met by USG.
- For high sustained accuracy . . . for long, trouble-free service under severe temperature and atmospheres . . . there's the Supergauge and Solfrunt Series.
- For less exacting applications there are thousands of gauges . . . cast case and drawn steel case units . . . each with components specially qualified for its particular function.
- Every gauge is backed with more than 50 years experience in gauge construction . . . with research that puts every type of gauge through simulated service conditions for months before it is marketed . . . with quality control that enables USG to guarantee performance in service.
- Buy USG gauges . . . pressure and temperature pilots, recorders and controllers . . . transmitters and thermometers . . . and be assured of guaranteed satisfaction in quality, performance and dependability.

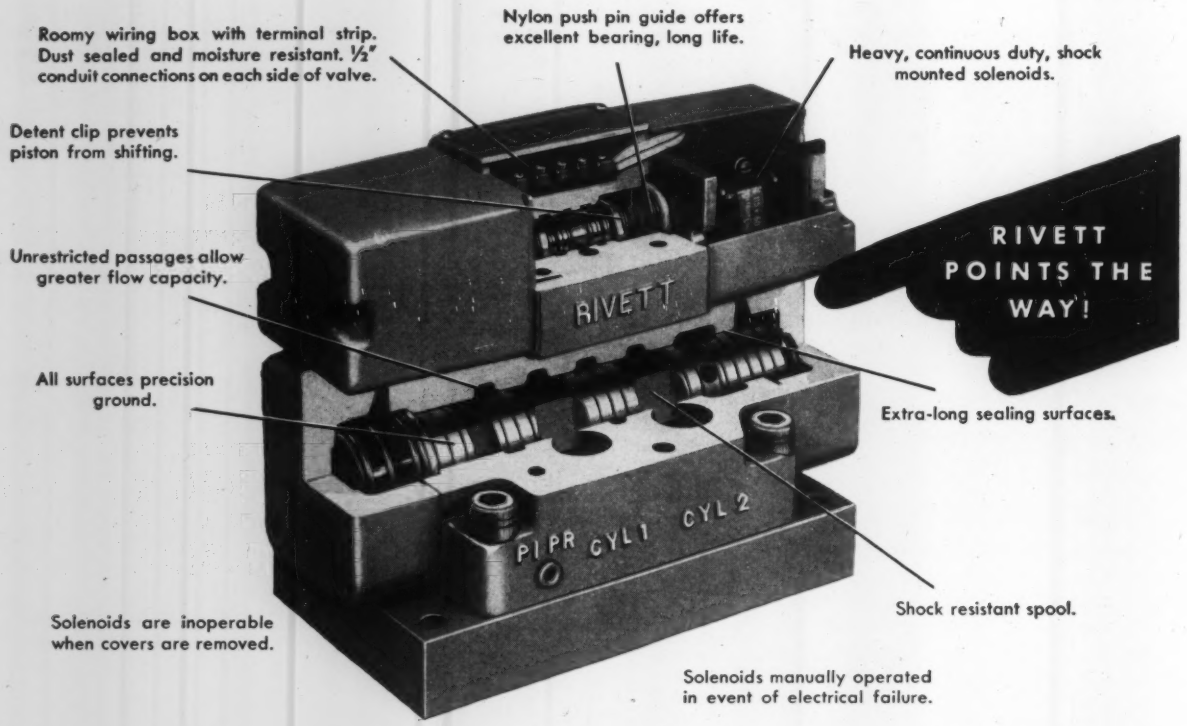
Consult the "Yellow Pages" of your phone book for the name of your USG distributor. Call him or write the factory for catalogs.

Supergauge and Solfrunt Reg. T.M.

USG UNITED STATES GAUGE
Division of American Machine and Metals, Inc.
Sellersville, Pa.
Home of the SUPERGAUGE

MORE THAN 50,000 TYPES OF GAUGES • SUPERGAUGES • SOLID FRONT GAUGES • RECEIVER GAUGES • TEST GAUGES • RECORDERS • CONTROLLERS • TRANSMITTERS • PSYCHROMETERS • AVIATION INSTRUMENTS

Circle 500 on page 19


Roomy wiring box with terminal strip. Dust sealed and moisture resistant. ½" conduit connections on each side of valve.
Nylon push pin guide offers excellent bearing, long life.
Heavy, continuous duty, shock mounted solenoids.
Detent clip prevents piston from shifting.
RIVETT POINTS THE WAY!
Unrestricted passages allow greater flow capacity.
All surfaces precision ground.
Extra-long sealing surfaces.
RIVETT
P1 PR CYL1 CYL2
Shock resistant spool.
Solenoids are inoperable when covers are removed.
Solenoids manually operated in event of electrical failure.

High Flow Capacity!

Rivett's New Solenoid Pilot Operated Hydraulic 1" Valve Is Rated at 28 G.P.M. and the 1½" Size At 82.5 G.P.M., At 15 Ft. Per Sec. Velocity.

- Reduces Back Pressure, Friction, Heat
- Opens and Closes Smoothly, Positively
- Mounts In Any Position
- 3000 P.S.I. Operation for Multi-Million Cycles
- Optional: Built-in Speed Controls
  Explosion Resistant
  Solenoid Enclosures

Forget about back pressure by specifying Rivett 6600's for service up to 3000 P.S.I. Reduce inventory! Select off the shelf: 2 basic sizes fit ⅜", ½", ¾", 1", 1¼" and 1½" I.P.S. Single and double solenoid. 7 spool designs. Meet *all* J.I.C. requirements.

RIVETT, INCORPORATED • Dept. MD-8
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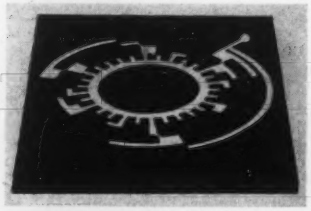
THE BETTER YOU KNOW HYDRAULICS THE BETTER YOU LIKE

Get Catalog No. 261 to aid your circuit design. Complete drawings, specifications, cut-away views, tables, diagrams!

Member National Fluid Power Association

RIVETT
"100"
HYDRAULIC VALVES

Circle 501 on page 19



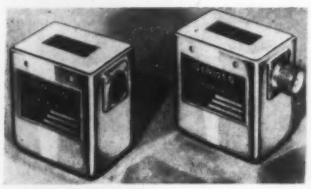
nate is either copper-clad or unclad. It is also available with printed circuits flushed to surface of material. **Mica Corp.**, 4031 Elenda St., Culver City, Calif.

Circle 705 on page 19

Acceleration-Sensitive Switch

for precision instrumentation in aircraft and missiles

Model DDS acceleration-sensitive switch, a magnetically-damped, oil-filled instrument, is readily adaptable for precision instrumentation requirements in high-speed aircraft and guided missiles. Switches are obtainable in ranges from ± 0.01 to ± 30 *g*. Unit opens and/or closes switch circuit at any *g* value specified, or for multiple *g* values. Normally-open, normally-closed, or multiple switch circuits can be provided. Model is obtainable for digital-output applications. Operational temperature range is -65 to 275 F. Unit



meets applicable military specifications for vibration and shock. **Genisco Inc.**, 2233 Federal Ave., Los Angeles 64, Calif.

Circle 706 on page 19

Internal-Pinion Counter

operates at speeds above 500 rpm

Internal-pinion decimal counter is available in two, three and four-digit types. Design provides maximum numeral size (1/4-in. high) in minimum of space. Models with five counts per revolution of input shaft are also furnished, in addi-

(*Continued on Page* 184)

These are the basic elements necessary to design and produce a precision built spring. To supply the above elements takes skill, experience and imagination . . . ingredients that Accurate Spring provides every one of their customers every day.

Accurate makes millions of springs a month—precision springs held to close tolerances by rigid quality control and inspection. Production schedules for large quantities are planned well in advance. Customers are assured of deliveries scheduled to their needs.

Proper packaging is necessary too, for ease of handling and speeded production. Untangling springs can be irksome and expensive.

These facilities are here to serve you. Just write, outlining your requirements and specifications.

Accurate Springs

SPRINGS
WIRE FORMS
STAMPINGS

ACCURATE SPRING MFG. CO., 3824 W. Lake St., Chicago 24, Ill.

Please direct inquiries to advertiser, mentioning MACHINE DESIGN

Warranted Two Years

New *Redmond* Single-Bearing MonoMotor

INCORPORATES DESIGN PRINCIPLES NEVER BEFORE AVAILABLE IN FHP SINGLE-BEARING MOTORS

The Tri-Flux design, described and illustrated at the bottom of this page, is available only in Redmond small-diameter motors. This design adds a third area of magnetic flux which greatly increases the efficiency and starting and running torques of the AM-4 over conventional old style single-bearing motors.

Redmond's Uni-Cast construction allows the precision manufacturing that results in a motor that is smooth-running and quiet and can be depended on to give years of service-free performance. Exact bearing alignment, uniform air gap, and the elimination of magnetic wedges assure long life and whisper-quiet operation.

The AM-4 is guaranteed not to leak oil in all-angle use or in shipment. The new positive oiling system provides an extra large oil reservoir for lifetime lubrication. Positive oiling is achieved through the forced recirculation of the lubricant, which is completely suspended and uniformly distributed in pure wool and nylon wicks.

Made of a durable, lightweight metal, this new single-bearing motor is considerably lighter than conventional old style models.

Designed for all-position mounting —vertical shaft up, shaft down, or any angle—and interchangeable to accommodate all standard brackets and special mounts, the AM-4 is adaptable to a wide variety of applications.

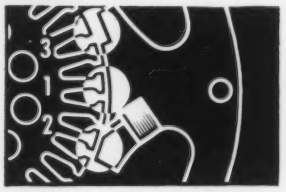
Designed Specifically for the Refrigeration and Air Conditioning Industries and Adaptable for a Wide Variety of Applications

The AM-4 is a 4-pole motor, 1550 r.p.m., 115 volts, 60 cycles. It is available in odd voltages and frequencies, and is rated at 1½, 4, 6, 9, 12, and 16 watts. ¼" external shaft diameter is projected in bearing to 5/16" for added strength. There are six lead outlets.

How Tri-Flux Design Improves Performance

The salient pole single phase induction motor has only one flux path—indicated by the white circle—between the field and the rotor. The motor is not self-starting—for commercial value a starting mechanism must be added.

The second white circle indicates the flux path added by wrapping a shading coil around the trailing pole tip. Power and uni-directional action are increased in this shaded pole induction motor, and it is now self-starting. This motor is now practical at low cost, and is used for applications requiring limited starting torque.



Note that a third flux path has been added at the leading pole tip. This was accomplished by Redmond's Tri-Flux design, whereby a "reluctance notch," which can be seen in the third white circle, is put in the leading pole tip. Efficiency and starting and running torques are greatly increased. New applications are opened to these improved, low-cost motors.

for Customer Satisfaction

Features All-Angle Operation

STANDARD AM-4 RATINGS

Totally Enclosed
Any Position Mounting

115V • 60 CYCLES • 4-POLE • 1550 RPM • ALL-ANGLE OPERATION

Model Number	Watts Output	AMPS	A ± 3/64	Hi Impedance Protected	Duty		Weight Lbs.-Oz.	Notes
					Fan	Mechanical		
*AM-4000J	1.5	.30	2 45/64	YES	YES	YES	2-2	1. All standard model numbers are clockwise rotation facing shaft end of motor. Opposite rotation supplied on request. 2. All motors comply with U. L. and C. S. A. electrical design standards.
*AM-4001J	4	.44	2 45/64	YES	YES	NO	2-2	
*AM-4200J	6	.46	2 61/64	YES	YES	YES	2-9	
*AM-4300J	9	.58	3 13/64	YES	YES	NO	3-1	
AM-4400A	12	.72	3 29/64	YES	YES	NO	3-9	
°AM-4401A	16	1.03	3 29/64	NO	YES	NO	3-9	

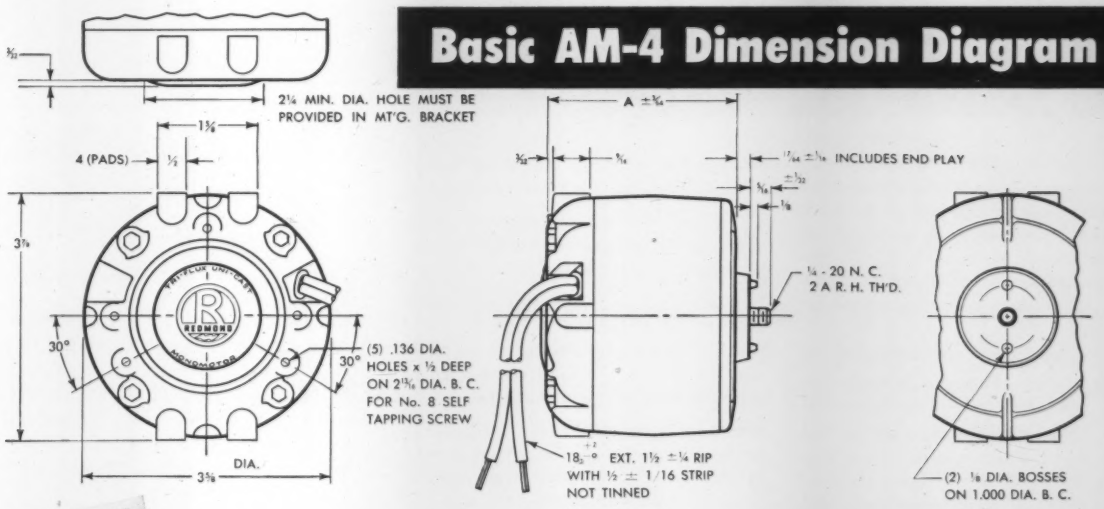
*May be operated on 50 cycles at 1300 RPM—Fan Duty—Hi-Impedance protected.
°Thermal protected.

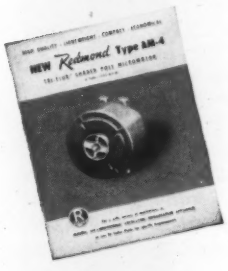
OPTIONAL FEATURES

Motors are supplied standard as shown. Also available are other features of special stud extensions, sleeving over leads, other lead material, feed-thru switches, plugs, terminals, conduit clamps and special lubricant as required for exceedingly high and low ambient operation.

Other performance ratings for various voltages, frequencies and loads can be supplied for your product. Our sales engineers will welcome the opportunity to assist you in developing the most practical motor for your applications.

Basic AM-4 Dimension Diagram


2¼ MIN. DIA. HOLE MUST BE PROVIDED IN MT'G. BRACKET
1⅜
4 (PADS)
½
3⅞
30°
30°
(5) .136 DIA. HOLES x ½ DEEP ON 2⅜ DIA. B. C. FOR No. 8 SELF TAPPING SCREW
DIA.
3⅝
A ±3/64
3/32
3/16
17/64 ±1/16 INCLUDES END PLAY
±1/32
3/16
1/8
¼ - 20 N. C. 2 A R. H. TH'D.
18 +2 -0 EXT. 1½ ±¼ RIP WITH ½ ± 1/16 STRIP NOT TINNED
(2) ⅛ DIA. BOSSES ON 1.000 DIA. B. C.



Send for Complete Performance Data

Write the Redmond Co., Owosso, Michigan, for the "AM-4 Bulletin." At your request we will have a sales engineer call.

The Standard of Dependability

Redmond COMPANY Inc.
OWOSSO, MICHIGAN

ADVERTISED IN The Saturday Evening POST

THE BIG NAME IN SMALL MOTORS

BUILD YOUR BUSINESS ALONG THESE LINES

with BIJUR Automatic Lubrication

By incorporating the Bijur System into your designs, you can offer substantial operating economies which progressive users now demand. For example, in the metalworking field 75% of machinery users prefer "built-in" automatic lubrication on the machines they buy.

Costly hand lubrication is eliminated.

Production time is saved because machines are oiled while in operation.

Bijur Automatic Lubrication is the best friend a bearing ever had. Every bearing is automatically fed a metered shot of oil at predetermined intervals.

Inaccessible bearings that require regular lubrication are never neglected.

There can be no problem of work spoilage or bearing headaches caused by over lubrication.

Leading machine builders have standardized on Bijur for a quarter of a century. Bijur puts the accent on engineering design – to satisfy the specific requirements of your machines.

Our engineers can show you how to build increased dependability into your machines, whether they are in production or still on the board.

0-4

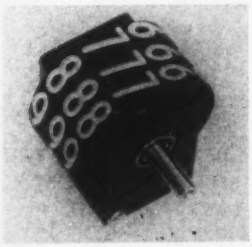
Write for literature and engineering data.

3370

BIJUR
LUBRICATING CORPORATION
Rochelle Park, New Jersey
Pioneers in Automatic Lubrication

New Parts

(*Continued from Page* 181)

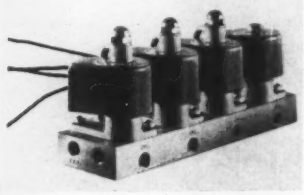


tion to direct-drive types. Masks with fixed zeros are available for a unit hundreds count. **Bowmar Instruments Corp.,** Plant 2, 2415 Pennsylvania St., Ft. Wayne 4, Ind.

Circle 707 on page 19

Solenoid Valves
are miniature units for manifold mounting

Designed for manifold mounting, two and three-way solenoid valves can be grouped on a common body, eliminating separate pipe connections to each valve. Bodies are forged brass with crown-type seats. Solenoids have stainless-steel cores and soft composition discs for tight closure. Each valve can be removed from manifold body without disturbing other valves or pipe connections. Valves



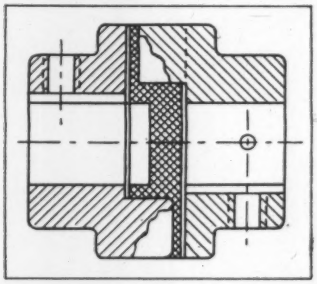
can be mounted in any position. They handle air, gas, water, light oil and refrigerants to a maximum temperature of 212 F. Pressure range is 0 to 300 psi. **Automatic Switch Co.,** Florham Park, N. J.

Circle 708 on page 19

Flexible Coupling
transmits load through cushion compression

L-075 cast-aluminum flexible coupling uses a one-piece spider-type load cushion. Load is transferred entirely by cushion compression, eliminating wear and abrasion on metal jaws. Entire spider can be

reversed to provide longer service life. Cushions are Buna-N, oak-tanned leather, Bakelite, or Bakelite and Buna-N combination. Coupling can be equipped for severe operating conditions, including exposure to oils, chemicals, water,



steam and abrasion. Unit is rated for loads from 1/10-hp at 100 rpm to 2 hp at 3600 rpm. Bore sizes range from ¼ to ⅞-in. in 1/16-in. increments. **Lovejoy Flexible Coupling Co.**, 4882 W. Lake St., Chicago 44, Ill.

Circle 709 on page 19

Hermetic Seal-Material

seals to 300 series stainless steels

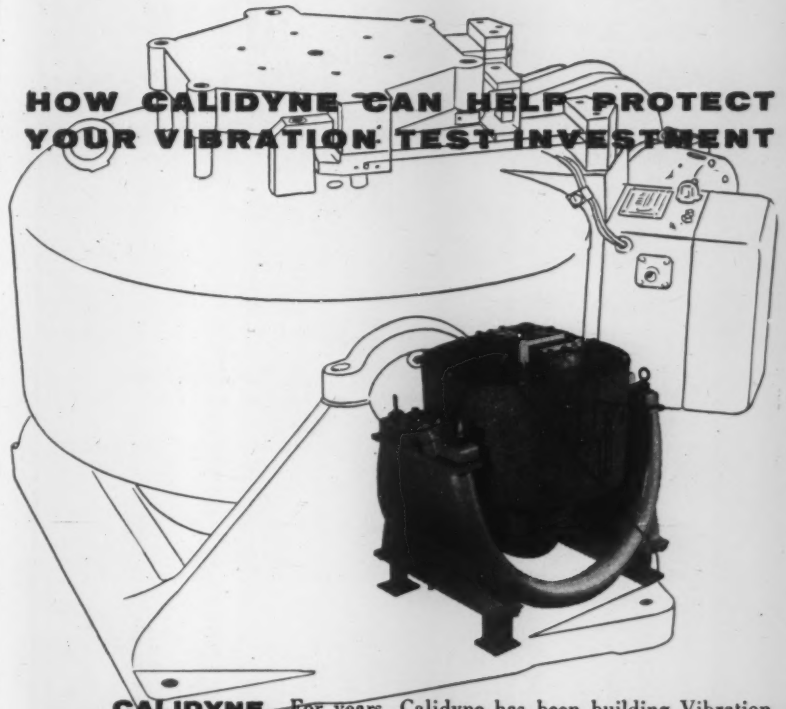
Ceramicite C-200 compound possesses excellent electrical characteristics and high pressure integrity at temperatures to 1100 F. It hermetically seals to 300 series stainless steels, assuring helium-leak-tight seal that withstands severe thermal shocks. Breakdown voltage is extremely high, making material useful for high-voltage feed-through bushings at elevated temperatures. Material is acid and alkaline resistant. C-200 is available as preforms, or as complete seals. **Consolidated Electrodynamics Corp.**, 300 N. Sierra Madre Villa, Pasadena, Calif.

Circle 710 on page 19

Digital Clock

for timing applications

This digital clock is a multiple-output unit which serves as a time source for data loggers, data-handling systems, computers, digital-time displays and other applications. It also functions as a 24-hr program controller. Output is a nonambiguous, parallel, decimal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Circle 504 on page 19

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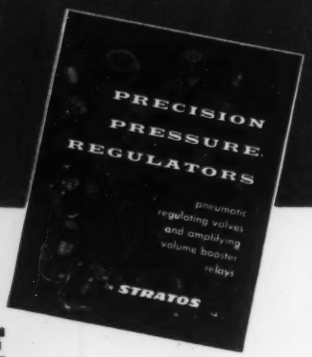

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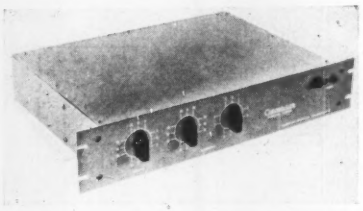
Circle 506 on page 19

New Parts

contact closure pattern, based upon 24-hr time. Up to three completely independent parallel outputs can be supplied in one unit. Digital clock utilizes printed-



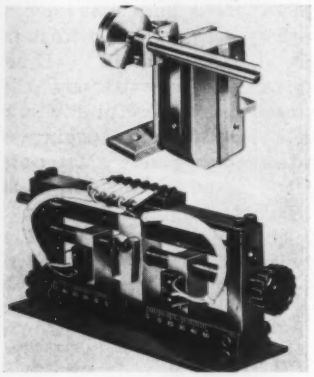
circuit techniques for digital circuitry. Circuit design eliminates load switching at printed circuit. Output circuits are rated at 0.5 amp, 110 v ac or dc. Time setting and adjustment are accomplished by direct knob settings on face of clock. **Chrono-Log Corp.**, Dept. MD, P. O. Box 4587, Philadelphia 31, Pa.

Circle 711 on page 19

Limit Stops

control mechanical or electromechanical functions

Two types of limit-stop devices for controlling mechanical or electromechanical functions are adaptable to a variety of rotational control applications. Limit stop BP-525 (top) is a cam-operated actuating



or limiting device which consists of a single-pole, double-throw microswitch and two adjustable matching cams. Cams can be preset to provide circuit make-or-break points over any desired rotational arc. Cam assemblies are available for a combined range in degrees of valley of either 0-180 or 180-270. Limit stop BP-522 (bot-

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Scoop...

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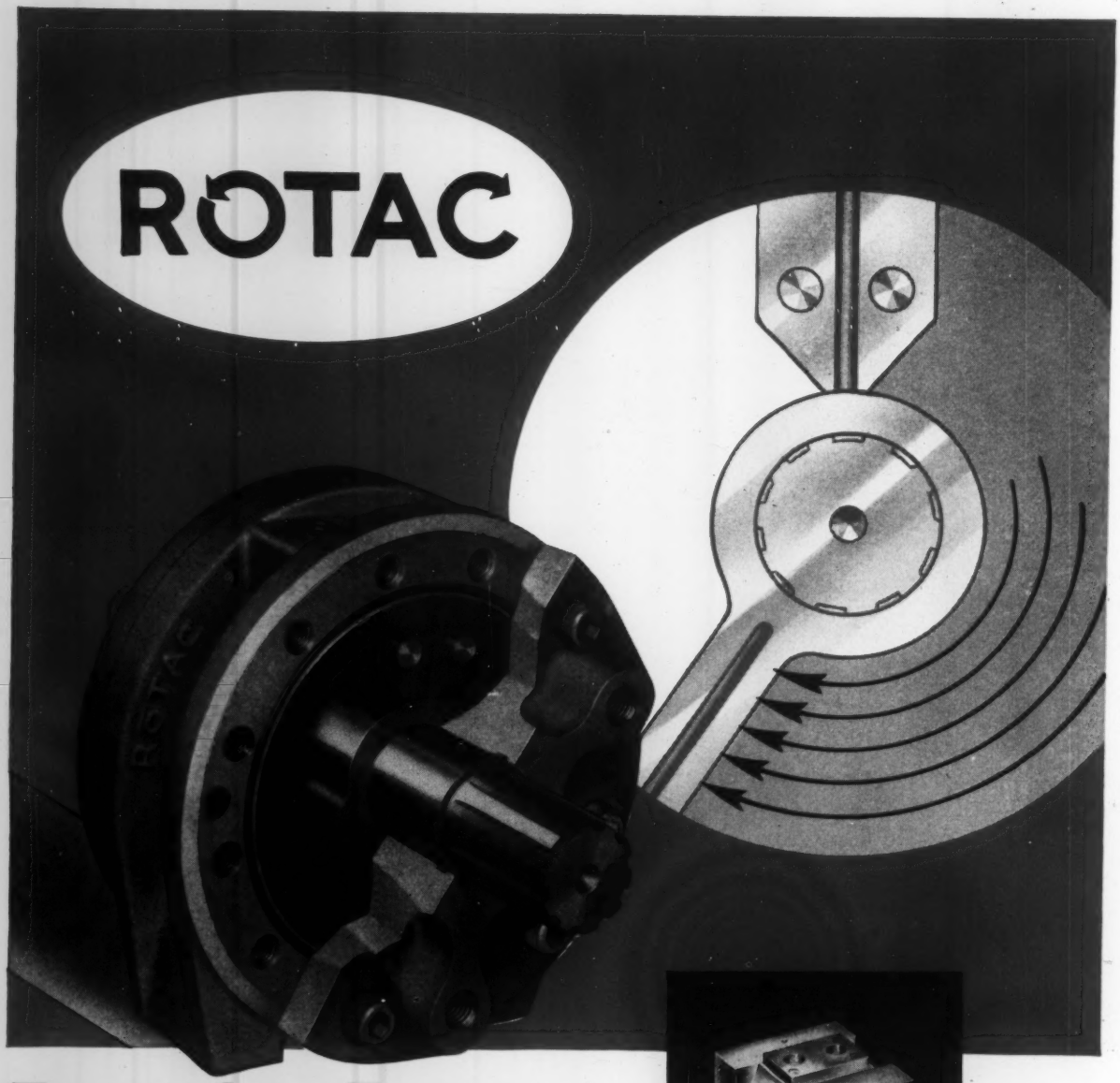
Circle 507 on page 19



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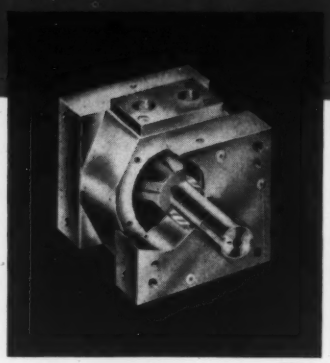

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FREE LITERATURE

If you move *anything*, then you'll want detailed information on Rōtac. Learn how this rotary power is used throughout industry in thousands of applications. Complete with photos, schematics, engineering data, etc. 57-59

Circle 508 on page 19

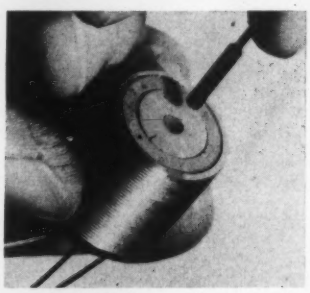
tom) provides both electric and mechanical stop operation by de-energizing driving motor before mechanical limit is reached, preventing extreme mechanical shock. Stop positions are manually adjustable to limits between 1 and 100 revolutions of input shaft. **Helipot Corp.**, Div. of Beckman Instruments Inc., Newport Beach, Calif.

Circle 712 on page 19

Differential Transformer

has low null voltage

Frictionless differential transformer, which makes possible low-impedance circuitry, has a null voltage of less than 2 mv. Coil, which is ⅞-in. long and ⅞-in. OD, is designed for an armature range of



±0.020-in. Output is linear within 1/10 of 1 per cent; input is 6.3 v at 400 cps. Use of glass-impregnated melamine bobbin, silicone vacuum impregnated coil, and Teflon-insulated wire provides continuous operation at any temperature to 400 F. **Automatic Timing & Controls Inc.**, King of Prussia, Pa.

Circle 713 on page 19

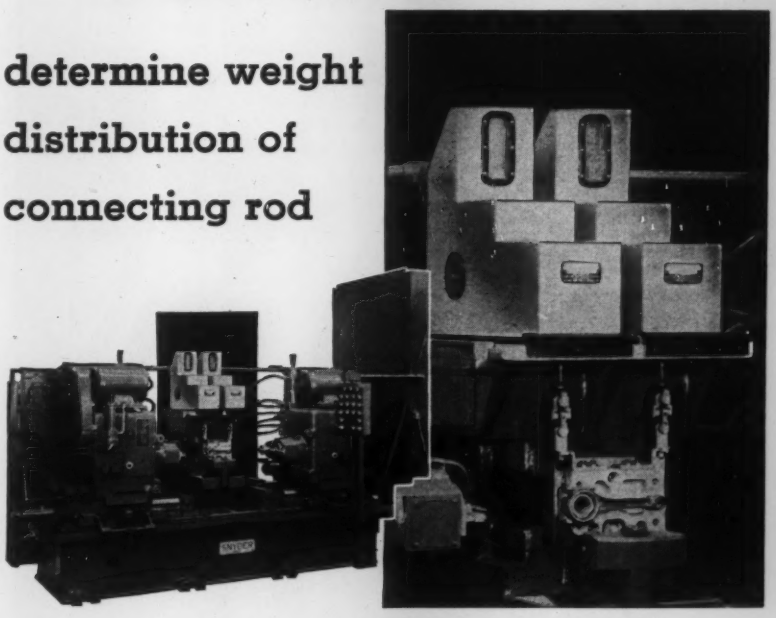
Component Clips

for mounting on printed-circuit boards

Component clips possess excellent holding features under vibration and shock. Mounting tabs spaced for 0.1-in. grids are used instead of riveting. Tabs, which take five 90-deg bends without fracturing, are inserted manually or automatically into 3/64-in. diam holes in printed board and bent over underneath to clinch clip in place. Clips and tabs, of beryllium copper finished by electrotinning

Exact Weight Scales

determine weight distribution of connecting rod



automatically set machine for correct stock removal

PERFECT BALANCE is assured on connecting rods by the use of two EXACT WEIGHT SHADOGRAPH scales built into this Snyder Milling Machine. Closer tolerances are obtained — operation is entirely automatic.

A pair of EXACT WEIGHT scales were specially designed to weigh both ends of workpiece on special hangers attached to scale beams. Scales register amount each end is out of balance and automatically transmit signals that set up units on either side. Balancing is accomplished in one pass milling and conforms to tolerances of 1/16 oz. (1.7 grams) on either end and overall weight. Any rod not meeting maximum machining dimensions is automatically rejected.

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Circle 509 on page 19

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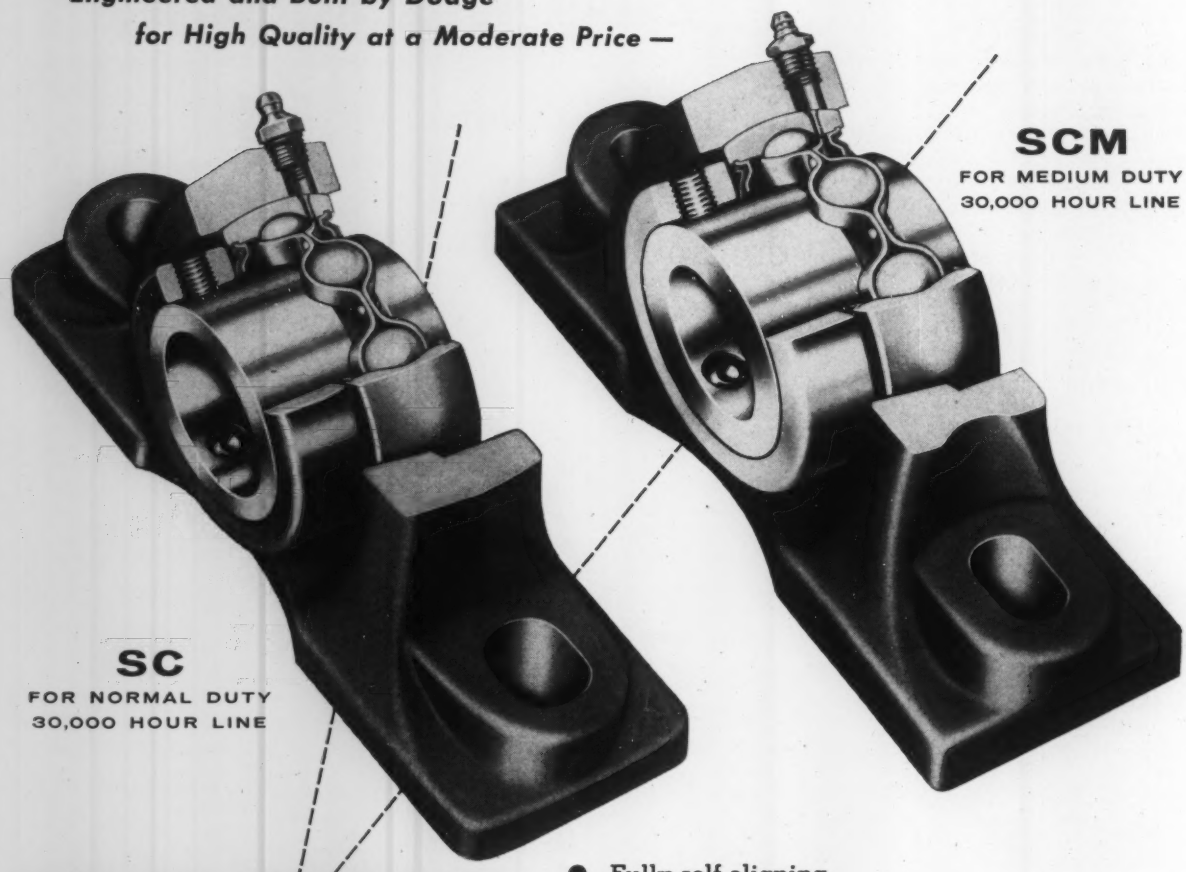

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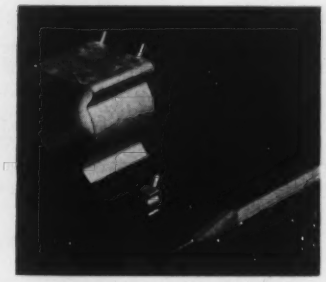
Circle 510 on page 19



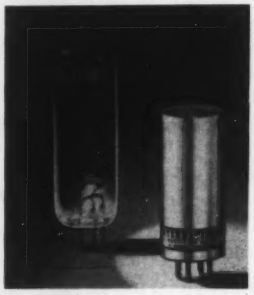
over copper flash, are of one-piece construction. Clips maintain tight grip on components over vibration range from 5 to 50 *g*. They are available for nine component diameters from 0.170 to 1 in. **Atlas E-E Corp.**, 47 Prospect St., Woburn, Mass.

Circle 714 on page 19

Silicon Rectifier

replaces vacuum-tube unit

Tube base mounted silicon replacement for vacuum-tube rectifier provides cool operation, long life and resistance to vibration and shock. The S6X4 (right), a direct replace-



ment for the 6X4 full-wave high-vacuum rectifier tube (left), features output of 85 ma dc maximum, input voltage of 400 v rms, and maximum peak current of 225 ma. Unit plugs directly into the 6X4 vacuum-tube socket. **International Rectifier Corp.**, 1521 E. Grand Ave., El Segundo, Calif.

Circle 715 on page 19

Phosphor Bronze Strip

for electronic and electrical applications

Silver-clad phosphor bronze strip is for use in electronics and electrical industries. Process employed to clad overlay of silver to phosphor bronze eliminates use of brazing alloys containing zinc, cadmium or other low vapor-pressure metals. Material is available in thickness tolerances of ± 0.0001-in. to mill limits as low as 0.0005-in. thick. Ratio of silver to bronze is variable according to requirements. Material is useful in applications where high ambient temperatures are involved. **American Silver Co. Inc.**, 36-07 Prince St., Flushing 54, N. Y.

Circle 716 on page 19

Ceramic Triode

provides sustained performance to 300 C

Ceramic planar triode, designated 3CX100A5, provides long life, full ratings to 60,000 ft, low interelectrode leakage and sustained per-

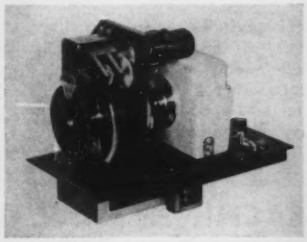
formance at temperatures to 300 C. It can be employed to 3000 mc. **Eitel-McCullough Inc.**, Application Engineering Dept., San Bruno, Calif.

Circle 717 on page 19

Servo Digitizer

digitalizes an ac input signal

Typical applications of the SL-1004 servo-driven digitizer include ground and flight instrumentation, analog translation to feed digital computers, as an input to a card



or tape system, and for laboratory demonstrations. Unit is designed to digitize an ac input signal. It operates directly from 400-cps line,

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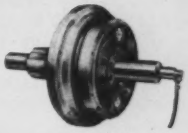

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Circle 511 on page 19

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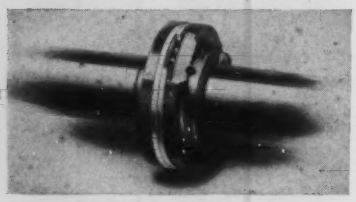

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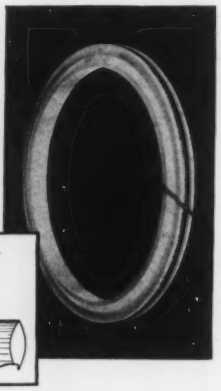

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Circle 512 on page 19

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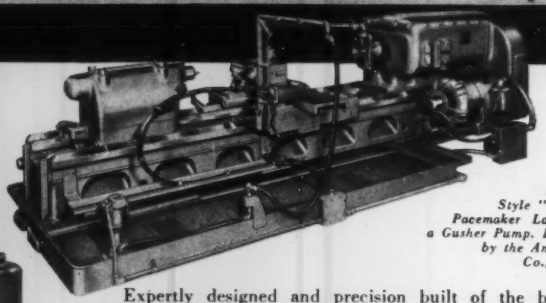

Illustrated is a 32" Style "1" De Luxe Model Pacemaker Lathe equipped with a Gusher Pump. Lathe manufactured by the American Tool Works Co., Cincinnati, Ohio.

Type 9050

Expertly designed and precision built of the best materials, by the originators of this type pump. Gusher Pumps give you high quality at reasonable cost. The wide acceptance of Gusher Pumps by the metal cutting industry is your assurance of their efficiency in operation, low maintenance cost, and long trouble-free life.

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Circle 513 on page 19

New Parts

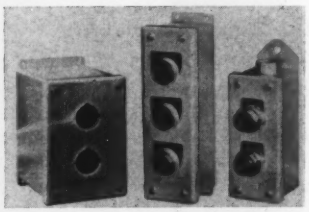
and includes a miniaturized, high-gain transistor-magnetic servo amplifier and power supply. Output is binary-decimal, and encoder shaft is driven ±170 deg from null. Static error is 0.15 per cent of full scale. **Industrial Control Co.**, 805 Albin Ave., Lindenhurst, L. I., N.Y.

Circle 718 on page 19

Pushbutton Enclosures

are oiltight units in three types

Welded steel oiltight pushbutton enclosures receive any regular make of oiltight pushbutton control unit. They are available in extra deep, slim and pendant



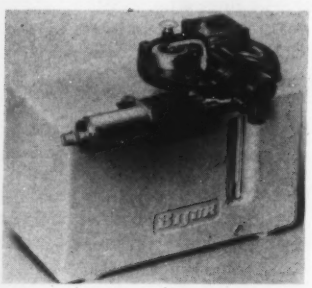
styles. Ten extra-deep unit sizes accommodate from 1 to 25 pushbuttons. Slim enclosure can be mounted vertically or horizontally, and holds from 1 to 10 pushbutton units. Pendant type has a conduit hub, and accommodates from 1 to 8 units. **Hoffman Engineering Corp.**, Anoka, Minn.

Circle 719 on page 19

Hydraulic Lubricator

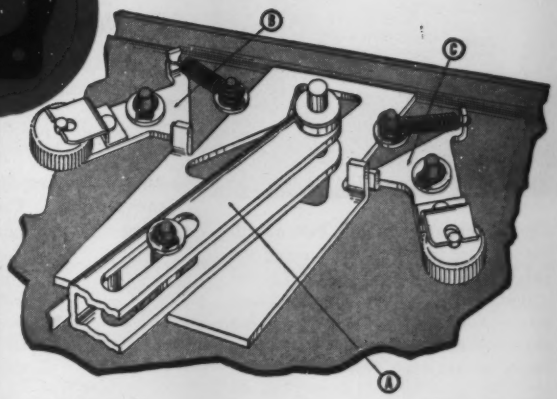
delivers 2 cu cm of oil per lubricating cycle

Cyclic Y hydraulic lubricator is for use in applications where lubricant discharge per machine cycle is relatively small. Unit operates on any hydraulic line pressure from 500 to 3000 psi and delivers 2



Waldes Truarc grip rings used on die-cast studs eliminate threading, tapping, other costly machining

Mark Simpson Manufacturing Co., Long Island City, N. Y., uses Waldes Truarc series 5555 Grip Rings to secure parts to studs of the zinc die-cast base of its "Masco 500" portable tape recorder.
The rings—which need no grooves—replace nuts, screws, cotter pins and other types of fastening devices which require threading, tapping, drilling and other expensive machining operations. Because a single cracked or broken stud would render the entire cast base useless—and with it, all assembly completed to that point—the rings also eliminate extremely costly rejects.



Pivot Assembly of shift lever (A) is secured by a single Waldes Truarc Grip Ring and washer. Because the washer must be installed over the shift level in a sliding fit, critical tolerances would have to be maintained if a screw or cotter pin were used. The Truarc Grip Ring eliminates that problem: it requires no groove and may be seated over the washer at any point on the stud, automatically compensating for accumulated tolerances in the parts. BRAKE ASSEMBLIES (B and C) use Grip Rings to secure the brake wheel and spring subassemblies. Here again problems of critical tolerances are avoided and expensive rejects eliminated.

Whatever you make, there's a Waldes Truarc Retaining Ring designed to improve your product... to save you material, machining and labor costs. They're quick and easy to assemble and disassemble, and they do a better job of holding parts together. Truarc rings are precision engineered and precision made, quality controlled from raw material to finished ring.

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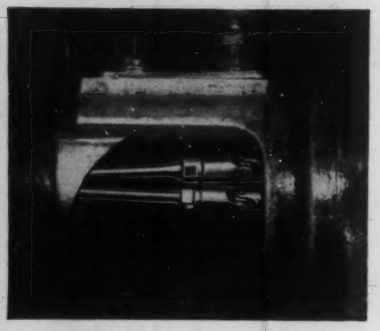
WALDES TRUARC Retaining Rings, Grooving Tools, Pliers, Applicators and Dispensers are protected by one or more of the following U. S. Patents: 2,382,948; 2,411,426; 2,411,761; 2,416,852; 2,420,921; 2,428,341; 2,439,785; 2,441,846; 2,455,165; 2,483,379; 2,483,380; 2,483,383; 2,487,802; 2,487,803; 2,491,306; 2,491,310; 2,509,081; 2,544,631; 2,546,616; 2,547,263; 2,558,704; 2,574,034; 2,577,319; 2,595,787, and other U. S. Patents pending. Equal patent protection established in foreign countries.

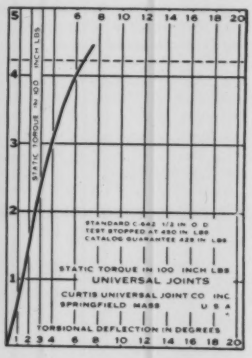
Solving a breakage problem AT CLOSE QUARTERS



The manufacturer of this button-drilling machine had a tough problem: the universal joints on these parallel shafts carried such a torque load there were frequent complaints of breakage . . . yet the close centers prohibited use of a larger joint.

THE SOLUTION was a Curtis Universal Joint of the same size.

Torque Curve ½" Curtis Universal Joint


STATIC TORQUE IN INCH LBS
TORSIONAL DEFLECTION IN DEGREES
STANDARD C-662 1/2 IN O D
TEST STOPPED AT 450 IN LBS
CATALOG GUARANTEE 428 IN LBS
STATIC TORQUE IN 100 INCH LBS
UNIVERSAL JOINTS
CURTIS UNIVERSAL JOINT CO INC
SPRINGFIELD MASS U S A

This is only one of many problems solved by Curtis Joints — size for size the strongest universal joints designed for industry. Selected materials, precision engineering, and over 30 years' experience manufacturing universal joints make them that way.

14 SIZES ALWAYS IN STOCK —
3/8" to 4" O.D. (6" joints on special order)

Not sold through distributors. Write direct for free engineering data and price list.

TRADE MARK **CURTIS**

UNIVERSAL JOINT CO., INC.

5 Birnie Avenue, Springfield, Mass.

As near to you as your telephone

EXCLUSIVELY A MANUFACTURER OF UNIVERSAL JOINTS SINCE 1919

Circle 515 on page 19

New Parts

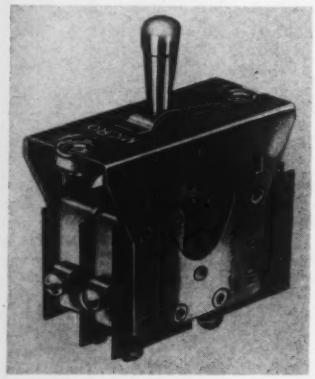
cu cm of oil per lubricating cycle. Any one of seven different lubrication cycles can be obtained by resetting hydraulic piston stroke adjustment. Reservoir capacity is 6 pt. **Bijur Lubricating Corp.**, 151 W. Passaic St., Rochelle Park, N. J.

Circle 720 on page 19

Toggle Switches

are three-position units with safety catches

Three-position toggle switches have safety catches to guard against accidental toggle-lever movement. Catch holds toggle lever in set position, and pull of



0.109-in. is required to release lever for movement. Switches are for mobile, marine, electronic and aircraft applications. All units have single-pole, double-throw arrangement. One switch contains two basic switching units in each assembly; the other has four switching units. **Minneapolis-Honeywell Regulator Co.**, Micro Switch Div., Freeport, Ill.

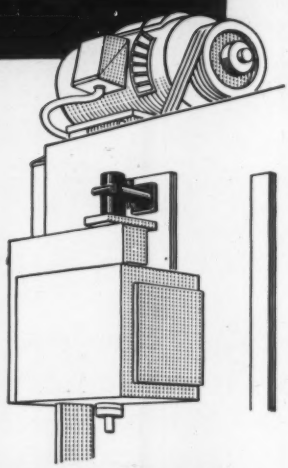
Circle 721 on page 19

Polyethylene Resin

for sheet extrusion and thermoforming

Alathon 31 polyethylene resin has high viscosity to resist sagging during thermoforming. It is easily extruded into sheet and shaped into finished parts when drawn over thermoforming mold. Parts fabricated have glossy surface, resist environmental stress cracking, are tasteless, odorless and nontoxic. Material can be calendered

ANGLgear® simplifies 'switch installation



Drawing based on photo shows ANGLgear drive for rotary limit switch on 75-ton Niagara punch press. ANGLgear's compactness and universal mounting feature helped simplify design of entire switch installation.

Ease of mounting was one of several important reasons why Niagara Machine & Tool Works, Buffalo, N.Y., selected ANGLgear to drive the rotary cam limit switch on its Series E power presses. The fact that ANGLgear can be mounted four different ways makes it easy to design into almost any power transmission system.

Other ANGLgear features that impressed Niagara engineers were compactness, quality construction, and precision gearing. Also ANGLgear cost less than other right-angle drives considered.

If you work with mechanical power transmission, there is an excellent chance that standardized ANGLgear can help you simplify design and reduce costs wherever 90° power takeoff is involved.

Completely enclosed, permanently lubricated, ANGLgear is available from stock in 1 to 5 hp ratings, with 1:1 or 2:1 gearing, and 2 or 3-way shafting.

See our literature in Sweet's Product Design File or contact your local distributor.

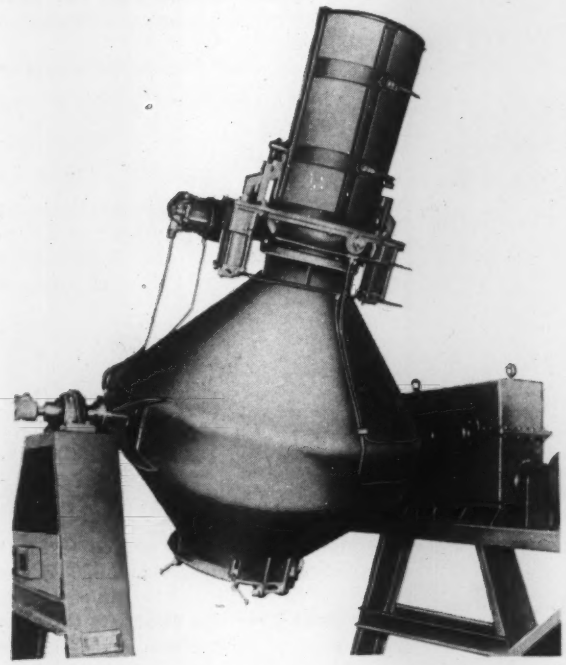
AIRBORNE®

AIRBORNE ACCESSORIES CORPORATION

HILLSIDE 5, NEW JERSEY

Circle 516 on page 19

How ORANGE *STAGGERED* ROLLER BEARINGS meet unusually rugged, precision requirements in Gemco Conical Blenders



"Over 10 years service without a replacement in any unit", reports General Machine Company, Newark, N. J.

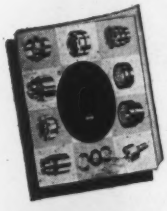
The speed reducers and pillow blocks of all Gemco Large Capacity Conical Blenders are engineered to efficiently handle the "tumble-over and spread action" of the blender. To withstand such severe treatment, and to handle extremes of 25,000 lb. load capacities, Orange "Staggered" Roller Bearings have been installed in these critical operating areas of Gemco Blenders since 1946, providing outstanding performance and eliminating maintenance and failure.

For extra heavy loads—severe service conditions—and to assure continuous trouble-free operation over years of heavy-duty operation, install Orange "Staggered" Roller Bearings.

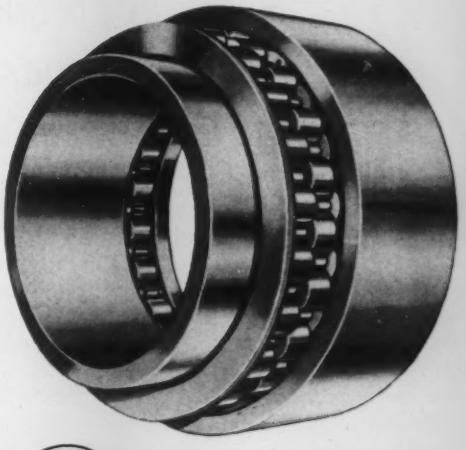
The exclusive staggered and meshed short roller arrangement, in place of conventional long rollers, gives this bearing many advantages:

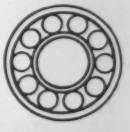
- **Extremely high load-carrying capacities**
- **Even distribution of raceway load over a maximum of contact points**
- **Multiple short rollers minimize skewing tendencies of fewer long rollers**
- **Longer bearing life under severe stress**
- **Solves design problems—cuts costs—saves space because smaller sizes often can be used.**

Orange "Staggered" Roller Bearings are available in a full range of standard sizes, fully interchangeable with other bearings in the 200 and 300 series. Engineering service and stocks in all industrial centers.



Write for 40-page Engineering Manual M-56 to obtain detailed information on the complete line of Orange Roller Bearings.





End views of an Orange "Staggered" Roller Bearing (upper) and a conventional bearing (lower) show graphically how many short rollers provide a multiplicity of contact points within the loaded zone.

ORANGE ROLLER BEARINGS

ORANGE ROLLER BEARING CO., Inc.
556 Main Street, Orange, N. J.

Needle Bearings — Staggered Roller Bearings
Journal Roller Bearings — Thrust Roller Bearings
Cam Followers

"That National Torque Converter certainly speeds up... and smooths down...shovel operations"

"Speeds up and smooths down" is the way an Alabama coal stripping operator described the job a National Torque Converter was doing on his new Lima shovel . . . and it would be hard to tell the story any better in several times that many words.

The National Torque Converter gives the operator a velvet-smooth flow of power for crowding, with immediate shock-free power multiplication if resistance is encountered . . . provides the positive, immediate, powerful response required for high-speed hoisting and for swing, travel and return. The engine cannot be stalled, greater capacity is obtained without shock loading, maintenance is reduced on all driving and driven mechanisms, cables, gears, engines and clutches last longer between overhauls.

National Torque Converters come in a full range of sizes from 100 to 1000 hp, and offer a variety of characteristics to meet individual job needs. You can specify them on the shovels and cranes of many major shovel manufacturers. For details, just write:

THE NATIONAL SUPPLY COMPANY

INDUSTRIAL PRODUCTS DIVISION

Two Gateway Center, Pittsburgh 22, Pa.

Pace-setters in the progress of industrial power transmission

New Parts

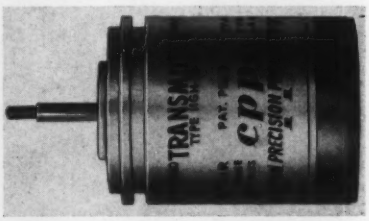
or extruded. It has melt index of 0.6 and density of 0.930. **E. I. DuPont de Nemours & Co. Inc.**, Polychemicals Dept., Wilmington 98, Del.

Circle 722 on page 19

Synchros

resist 450-F temperatures

Size 10 synchros are available as transmitters, transformers, differentials and resolvers. Transmitter is for direct turbojet engine



mounting and has passed tests at 450 F for 100 hr and 350 F for 1000 hr. Units are stainless steel. **Clifton Precision Products Co. Inc.**, 9014 W. Chester Pike, Upper Darby, Pa.

Circle 723 on page 19

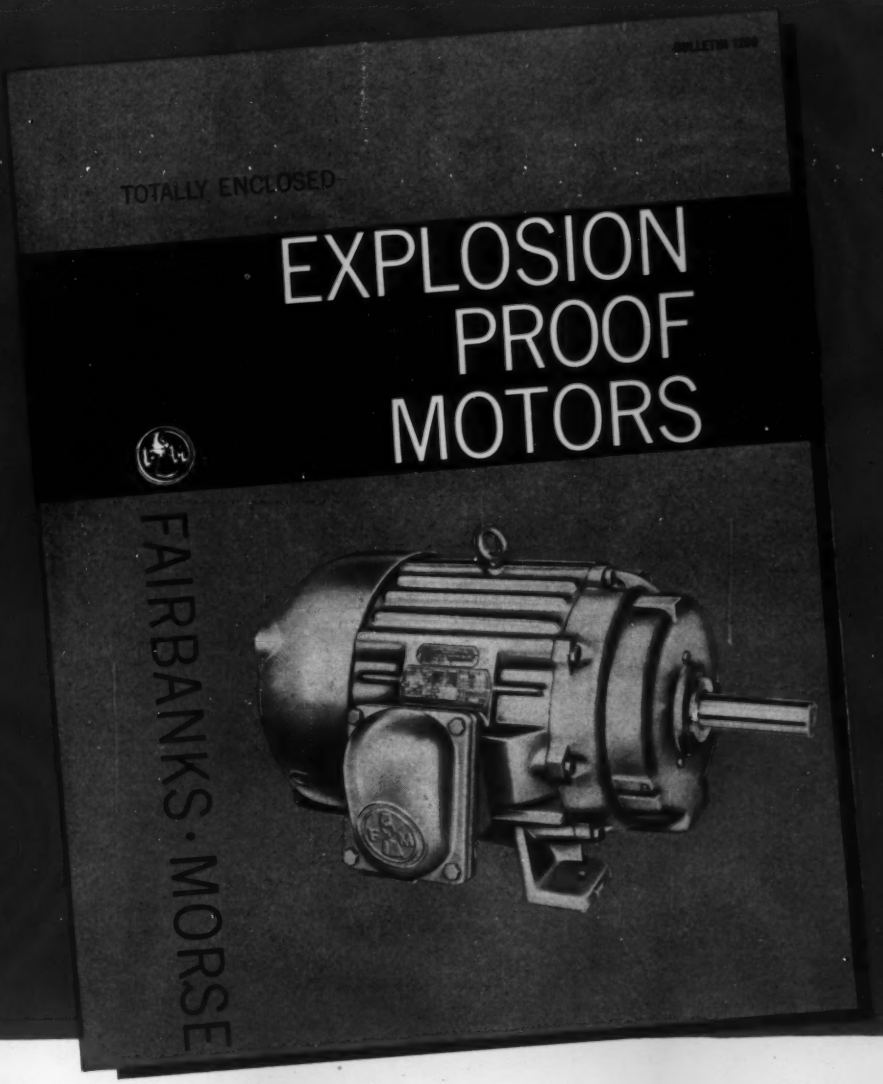
Pressure Controller

is servo actuated by pilot nozzle

Type 10 air-gaging manostat gives precise downstream pressure control over wide supply pressure variations. It does not drift with time or periodic shutdown, and remains stable through temperature

changes and supply or flow variations. Unit utilizes a high-gain servo system with main valve action controlled by pilot nozzle activated by slight pressure variances. Measuring element incorporates highly elastic metallic

NEWEST MOTOR TO CARRY UNDERWRITERS' LABEL



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All new inside and out—new, rugged frame design . . . for new, improved performance in all Class I, Group D, and Class II, Group E, F and G hazardous locations.

Get full information . . . send for Bulletin 1200 on new Fairbanks-Morse line of totally enclosed, explosion-proof motors. Write today: Fairbanks, Morse & Co., Dept. MD-822, Chicago 5, Ill.

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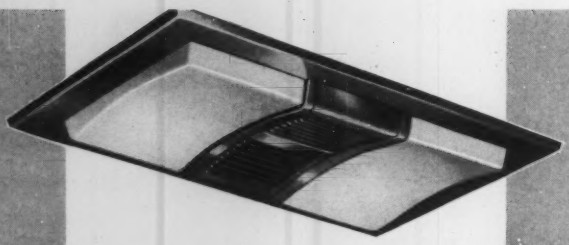
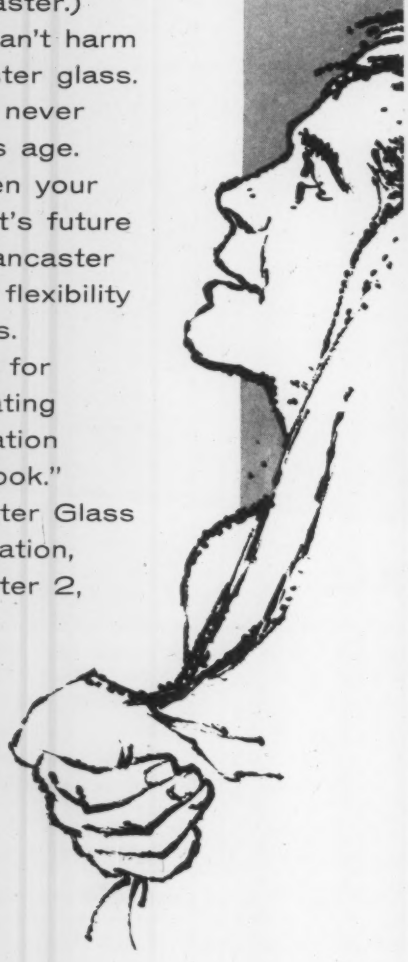


Glass just naturally glows with light.
Case in point:
This new bathroom ventilator-lamp by Berns Air-King with
Lancaster
diffuser lenses.
(Looks smarter, sells faster.)
Heat can't harm Lancaster glass.
And it never tells its age.
Brighten your product's future with Lancaster design flexibility in glass.
Write for illuminating "Application Handbook."
Lancaster Glass Corporation, Lancaster 2, Ohio.



New Parts

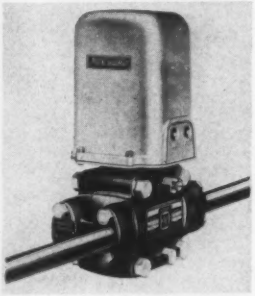
parts with practically no hysteresis or permanent deformation under working conditions. Unit is available in ranges of 2-25 and 3-60 psi in ⅛ and ¼-in. pipe sizes. **Bellofram Products Corp.,** Blanchard Rd., Burlington, Mass.

Circle 724 on page 19

Cell Transmitter

operates in temperature to 250 F

Integral - orifice differential - pressure transmitter cell measures and transmits small flows, with minimum range of 0.003 to 0.010-gpm of clean water and similar liquids and 0.010 to 0.040-scfm of air and other gases. Instrument has a manifold with removable orifice



through which measured fluid flows. Six standard orifices in bore sizes from 0.020 to 0.250-in. are available with transmitter. Removal of manifold permits change of orifice for new flow range. Transmitter range is adjustable between limits of 0-20 and 0-250 in. of water. Maximum working pressure is 1500 psi; maximum working temperature, 250 F. **Foxboro Co.,** Foxboro, Mass.

Circle 725 on page 19

Time Delay Relay

provides adjustable recycling

Model DED double-head Agastat time delay relay incorporates two-way action to provide adjustable recycling. Separate time delay can be set on each of two timing heads to permit adjustable on and adjustable off from 0.1 second to 15 minutes. Applications include use in laboratory equipment where recycling is important, in operations requiring continuous automatic re-

Circle 520 on page 19

Your customers may need this drive...

TO AUTOMATE YOUR MOTOR DRIVEN PRODUCTS...
GIVE THEM PRECISE, VARIABLE SPEED CONTROL...

Century Performance-Rated°
SELECTIVE SPEED DRIVE

How many of your customers could use the *full* potential of your product when given automatic operation by a Century Selective Speed Drive? Possibly more than you think.

Here's why. Predetermined, *automatic* manufacturing operations are faster, more accurate than manually controlled operations. A Century Selective Speed Drive on your product will respond to changes in operations—such as varying temperature, pressure, size, viscosity—and *automatically* adjust motor speed to fit the job.

Operating from AC, these drives offer a broad range of DC stepless speed control. They can regulate speed for individual drives or for precision interlocked multi-motor drives . . . can be used for jogging, normal or fast starts and stops, forward or reversing . . . and respond to a wide variety of remote control devices.

Century has more than 50 years' experience in engineering DC motors. For information on any motor application, call or write your nearby Century District Sales Office or Authorized Distributor.

Performance-Rated° MOTORS 1/20 to 400 H.P.

CENTURY ELECTRIC COMPANY

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Circle 521 on page 19

(Advertisement)

ADVANTAGES OF FLEXIBLE SHAFTING

For Power Drive and Remote Control

by

C. Hotchkiss, Jr.

Application Engineer

Stow Manufacturing Company

Flexible shafting has the following advantages over other type drives:

1—it is often the simplest method of transmitting power between two points which are not collinear or which have relative motion

2—eliminates exposed revolving parts

3—does not require accurate alignment

4—easy to install and maintain

Not Collinear—Where it is necessary to connect two shafts which are not collinear, a simple arrangement of a single belt or two universal joints will often do the job adequately. But, in many cases where the path of transmission is more complicated and would require a more expensive arrangement of mechanical components, flexible shafting provides a simple, low cost, efficient drive which is easy to install because it does not require accurate alignment. See example, figure 1, in which a 1¼-inch Stow flexible shaft is used to drive the auger on a G.L.F. bulk feed truck.

Flexible shafting also allows the designer greater freedom in locating either the drive or the driven component on a piece of equipment.

Fig. 1

Relative Motion — Where two shafts which have relative motion must be connected, flexible shafting is often the ideal means of transmission. In many cases it eliminates a much more complicated drive which would, necessarily, include telescopic joints; further, it eliminates the danger of exposed moving parts. See figure 2, which shows a ¾-inch Stow flexible shaft driving an Avery Rake built by the Minneapolis Moline Co.

Fig. 2

Other typical applications of this type are used on portable power tools when motors are too heavy to be mounted on the tool—such as portable grinders, sanders, paint scrapers, saws and tree tappers. And, since flexible shafting is not affected by vibration, it is an ideal drive for applications where a high degree of vibration is involved—such as in vibration testing tables and concrete vibrators.

Stow flexible shafts are available: for power drive applications in diameter sizes from ⅛-inch to 1¼-inches; for remote control applications in diameter sizes from ⅛-inch to 1⅝-inches. The 1¼-inch power drive shaft will transmit up to 10 HP while the 1⅝-inch remote control shaft will transmit up to 4000 lb. in.

For complete engineering data on flexible shafting, including selection charts, write for engineering bulletin 570.

STOW MANUFACTURING COMPANY

11 SHEAR STREET • BINGHAMTON, NEW YORK

New Parts

cycling and in standby electrical power equipment. Models include dial heads to simplify time adjustments. Dial heads are calibrated for accurate adjustment, and com-

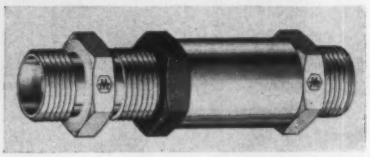
plete range of adjustment is accomplished with one revolution of dial. Four timing ranges are available in dial head. Single-pole, double-throw, double-break and double-pole, double-throw, single-break units are available. **Elastic Stop Nut Corp. of America,** A'G'A Div., Elizabeth, N.J.

Circle 726 on page 19

Flareless Union

is adjustable assembly

Adjustable flareless union is for use in aircraft and missile applications where space does not allow tubing to be sprung to accommo-



date the portion of tubing which must be positioned within connector. Assembly is available in − 4 to − 20 sizes. It can be used in hydraulic systems for 3000-psi service. **Weatherhead Co.,** Aviation Div., 300 E. 131st St., Cleveland, O.

Circle 727 on page 19

O-Ring Compound

for automotive and aircraft use

O-ring compound 119-70 fills seal requirements in valves, fuel-line couplings and carburetors of high-compression engines in automobiles and aircraft. It does not swell abnormally, and will not deteriorate in engine fuels. Compound is

Circle 522 on page 19

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Sixty thousand feet up and exceeding the speed of sound, jet flight imposes incredible demands upon engine components. Through constant research in close cooperation with the aircraft industry, American Welding has kept pace.

Today it supplies rings for every major U. S. jet engine manufacturer. New techniques have been developed to form and flash butt-weld metals like titanium and other hard-to-work stainless and heat-resistant alloys. This results in rings and other products of greatly improved quality... at reduced cost. These savings, amounting to millions of dollars yearly, are helping our nation get more for its defense dollar.

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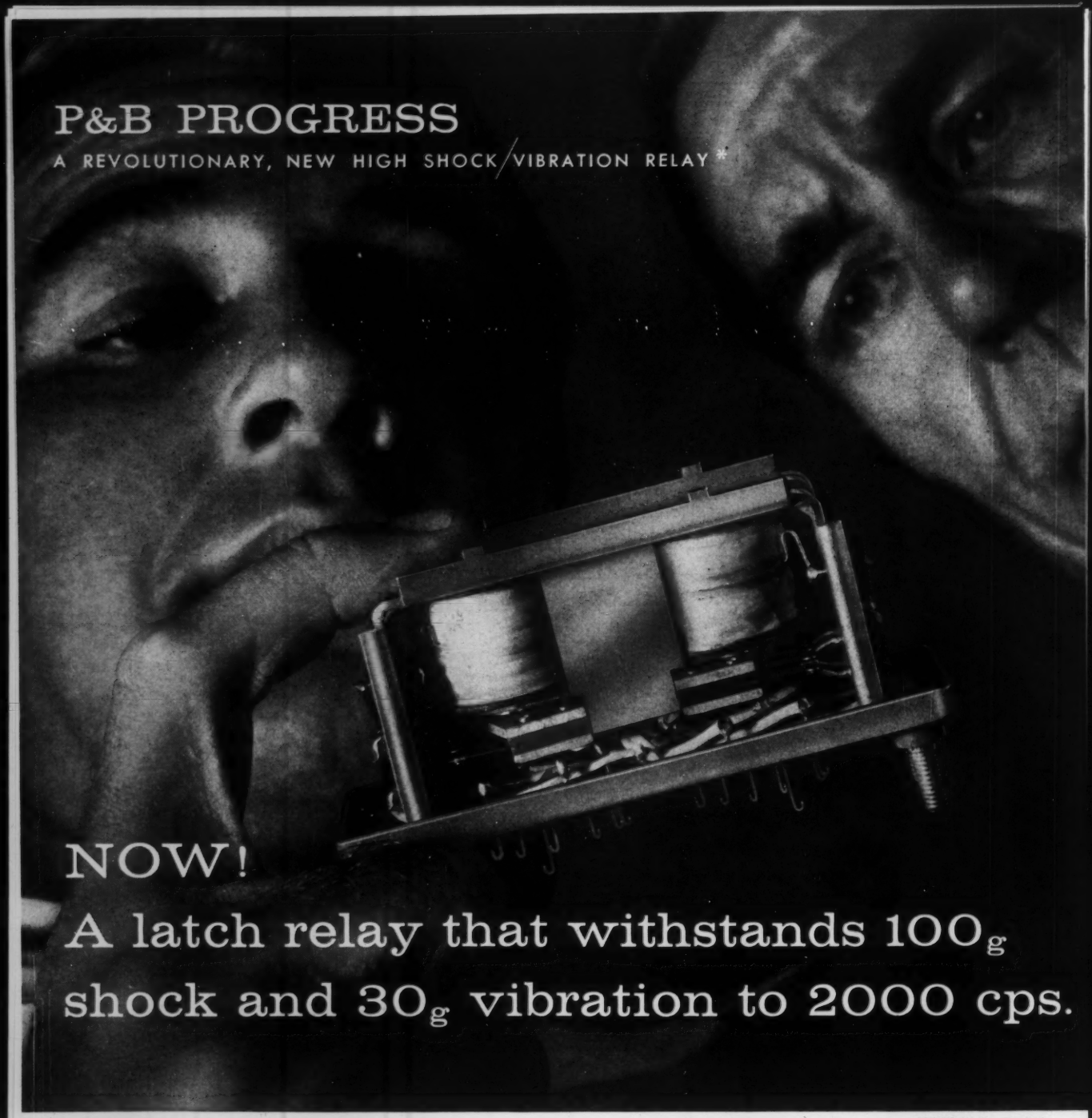
Circle 523 on page 19


P&B PROGRESS
A REVOLUTIONARY, NEW HIGH SHOCK/VIBRATION RELAY*
NOW!
A latch relay that withstands 100g
shock and 30g vibration to 2000 cps.

*KG RELAY (Pat. Pending)

ONLY 2.0 WATTS AT NOMINAL VOLTAGE FOR 12 MILLISECONDS EFFECTS ARMATURE TRANSFER

NEW POTTER & BRUMFIELD KG SERIES RELAY

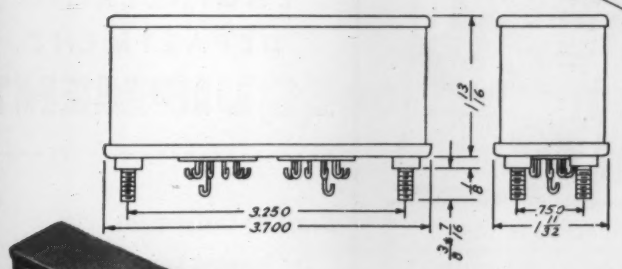
The new KG magnetic latch relay was designed by P&B engineers at the insistence of leading aircraft and missile manufacturers and their suppliers of control systems. A permanent magnet which locks the armature into position is the secret of the KG's dramatically high resistance to shock and vibration.

In addition to withstanding 30g vibration from 6 to 2000 cps, tests show the contacts will open for no more than 80 microseconds during 100g shock.

Armature transfer from one set of the 6PDT contacts to another can be made in approximately 12 milliseconds with only 2.0 watts at nominal voltage. The KG is rated for ambient temperatures from −65°C to +125°C.

The KG, together with other relays in the P&B "Star Series", has vastly increased the realm of relay reliability for critical applications demanding positive action of all components. Write or wire today for complete technical data.

POTTER & BRUMFIELD, INC., PRINCETON, INDIANA—SUBSIDIARY OF AMERICAN MACHINE & FOUNDRY COMPANY



STAR SERIES

KG RELAY

DESIGNATION: KG23DBH

GENERAL: Insulating Materials: Teflon, glass and ceramic.
Insulation Resistance: 100 megohms min.
Breakdown Voltage: 500 V. RMS.
Shock: 100g where contact openings less than 80 microseconds may be permitted.
Vibration: 30g 5 to 2000 cycles.
Ambient Temperature: —65°C to +125°C.
Weight: 13 ozs.
Pull-in-Speed: 12 MS using 310 ohm coil at 24 V. DC. (25°C).
Terminals: Two 11 pin multiple solder headers with hook ends for 3 #20/AWG wires.
Enclosures: Hermetically sealed only.
Dimensions: 1-11/32 x 3.700 x 1-13/16 (See drawing for width, etc.)
CONTACTS: Arrangements: 6 pole double throw.
Load: Dry circuit to 3 amps, 115 V. AC, resistive. 5 amps, 28 V. DC, resistive.
COIL: Power: 2.0 watts at Nominal Voltage.
Duty: Either coil may be left energized without damage to the relay.
Insulation: Teflon tape.
MOUNTINGS: Four ⅜ inch #8-32 studs on 3¼ x ¾ inch centers.

COIL DATA: (EACH COIL)

Voltage:	6 V. DC	12 V. DC	24 V. DC	48 V. DC	110 V. DC
Resistance: ±10% @ 25°C	14 ohms	55 ohms	310 ohms	835 ohms	5500 ohms

See What's New in P&B Progress at Booth 603, 604 WESCON, San Francisco, August 20-23

Potter & Brumfield, inc.
PRINCETON, INDIANA

Subsidiary of **AMERICAN MACHINE & FOUNDRY COMPANY Manufacturing Divisions also in Franklin, Ky. and Laconia, N. H.**

Mail the coupon below for further engineering data on P&B's new Star Series relays *plus* new compact catalog of standard type relays. If you need answers to a specific application problem, write in detail.

Potter & Brumfield, Inc., Princeton, Indiana
Attn: T. B. White, Brig. Gen. M.C. (Ret.)
Special Projects Engineer

Please send me complete data on the new Star Series relays, plus the new compact catalog of P&B standard relays.

Name_____
Company_____
Address_____
City_____ Zone_____ State_____

Circle 524 on page 19

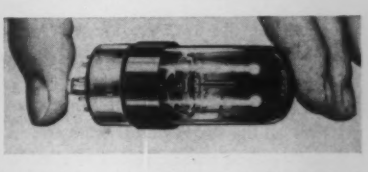
also effective for use in high-temperature service in aircraft diester-base synthetic lubricating fluids. It can be used with gasolines of all types, fuel oils (including No. 6), propane, butane and low-pressure home fuel gases. **Precision Rubber Products Corp.,** 3110 Oakridge Drive, Dayton 7, O.

Circle 728 on page 19

Temperature-Limited Diode

for voltage detection

Type 1236C temperature-limited diode is for service as an rms detector for differential voltmeters, as an rms detector for ac voltage and current stabilizers, or as a de-



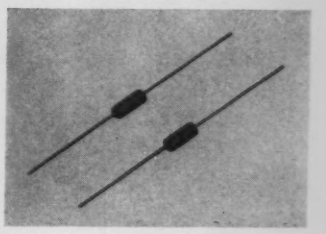
tector for dc voltage and current stabilizers. It has a T9 bulb with Bakelite base of 8-pin locking-in type. Average operating characteristics are cathode voltage of 1.9 v ac or dc, 440 ma, and plate voltage of 600 v dc, 0.7 ma dc. **Superior Electric Co.,** Dept. DO, 83 Laurel St., Bristol, Conn.

Circle 729 on page 19

Silicon Diodes

for computer service

Silicon diodes are designed for computer service and other applications requiring fast switching and operation under high tempera-



tures. Operating voltages extend to 200 v, and no derating is necessary up to a maximum temperature of 150 C. Switching time is 0.3 microsecond or less. **Transitron Electronic Corp.,** Melrose 76, Mass.

Circle 730 on page 19

Take ALL the Problems Out of Your Variable Speed Requirements

Put Lovejoy's exclusive individualized service to work for you...a complete line of variable speed pulleys and transmissions—plus personalized engineering guidance to assure full satisfaction.

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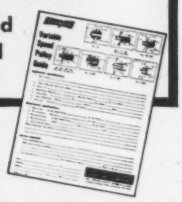
- Horsepowers: fractional to 15
- Constant belt alignment
- Instant speed changes while equipment is running
- Easily installed on new or old equipment.



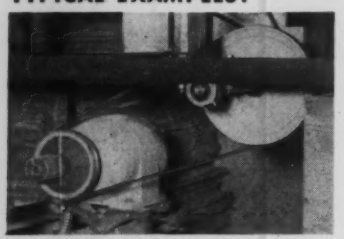
Here's how it works...

a simple and convenient two-step plan:

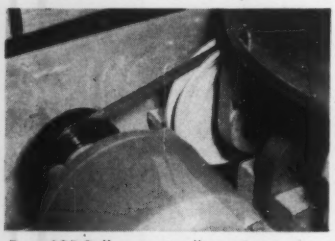
❶ Lovejoy sends you full information on the types of variable speed pulleys and transmissions available . . . along with a guide sheet to help you supply us with pertinent information on the type you need and the service you require.

❷ Depending on your requirements, Lovejoy rushes recommendations, blue prints, suggested solutions to problems . . . or, if you desire, will send a representative to give you first-hand assistance. For standard or relatively simple applications, cost quotations can be furnished immediately.

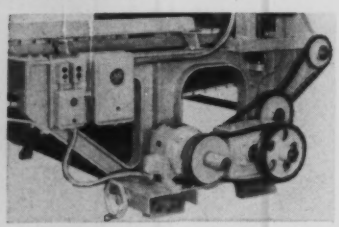
TYPICAL EXAMPLES:



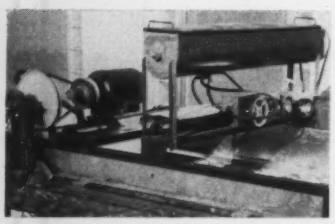
Type 160 Pulley and No. 200 Tilting Motor Base proved the right combination for a mailing machine.



Type 135 Pulley meets all requirements on a vibrating machine.



Proper drive for a slat bed rip saw is provided by a Type 302 Pulley.



This Lovejoy "double" solved a grading machine problem—Type 145 Pulley and No. 2 Select-O-Speed.

Save time and expense. Get your Variable Speed Pulley Guide by requesting Form 118F today.

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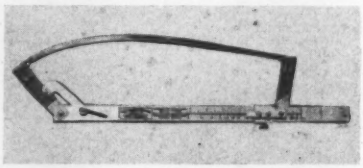
ENGINEERING DEPARTMENT EQUIPMENT

Drafting Instrument

for drawing long-radius circular arcs

Daniels curve is used in drafting where accurate circular arcs of long radius are required. It is also available in a modified form for drawing slightly irregular curves.



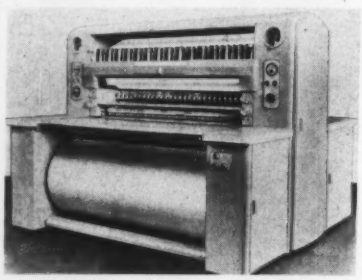
Flexible strip is protected against breakage by limit stops in unit without irregular curve adjusting feature. Five models are available with various ranges of adjustment and index markings. **Albert G. Daniels,** 109 Chalmers St., Winnsboro, S. C.

Circle 731 on page 19

Diazotype Printer

prints from masters to 54 in. wide

Tecnifax Hi-Q diazoprocesser is a high-output, ammonia-developing unit with electronically controlled speeds up to 125 fpm. Unit produces prints from translucent masters up to 54 in. wide. High printing speed is made possible by the use of a high-pressure, mercury-vapor lamp, rated at 150 w per in. New developing principle pro-



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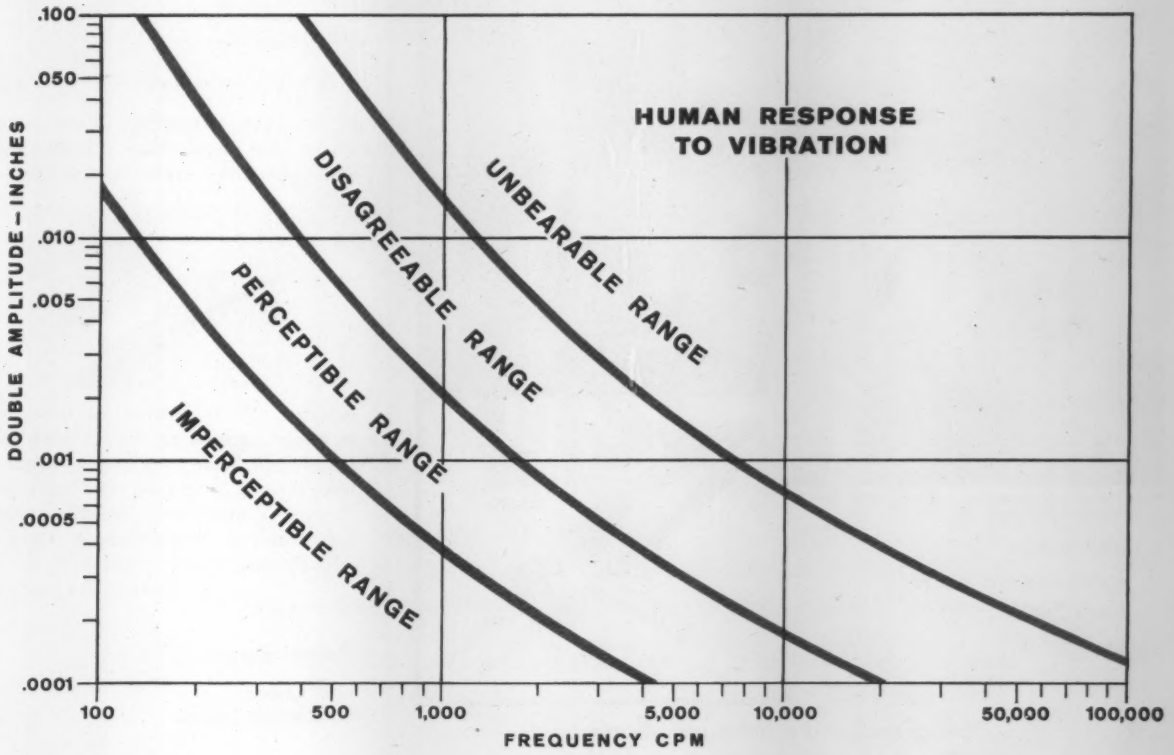

Vibration . . . shock . . . noise all lower production efficiency and lessen sales appeal.

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Circle 526 on page 19

Young SAMPLE FLUID COOLER

chosen for use on new

ATOMIC SUB "SKATE"

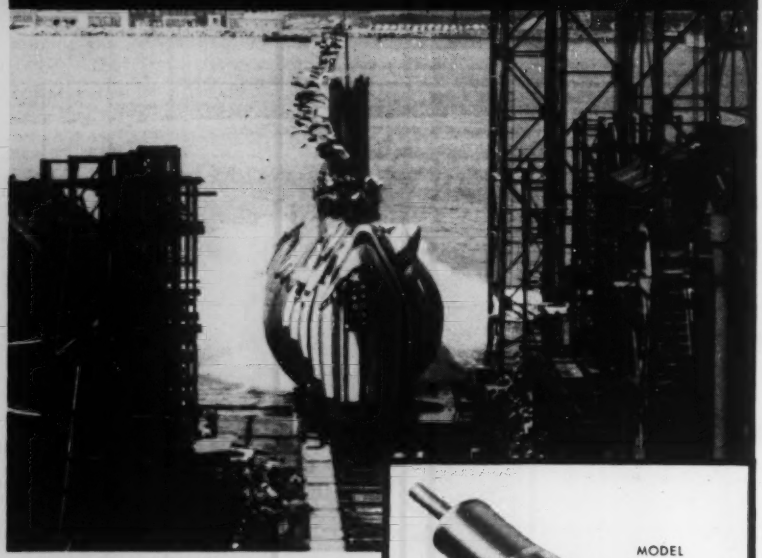
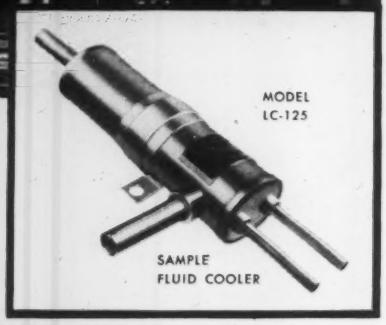


PHOTO COURTESY ELECTRIC BOAT DIVISION OF GENERAL DYNAMICS CORPORATION

Unit shown
cools reactor water
from 500° F.
to 150° F.



Young shell and tubular coil sample fluid coolers will reduce temperatures from 600° F. to 100° F. at pressures up to 1,500 psi. These small, compact units cool sample fluids for control testing purposes for pilot plants, boiler water samples, chemical and other high temperature and pressure process fluids.

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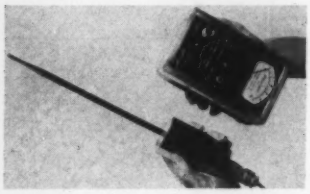
vides complete, uniform development of any diazo-sensitized material at any speed at which it can be printed. Feed board is continuously adjustable to different depths to handle small or large tracings. **Tecnifax Corp.**, Holyoke, Mass.

Circle 732 on page 19

Vibration Tester

is battery-operated

Model 305 vibration amplitude meter has inspection, production and preventive maintenance appli-



cations. It is calibrated directly in three ranges of 0.1, 1 and 10 mils full scale reading. Lightweight and portable, the unit is battery - operated. **International Research & Development Corp.**, 797 Thomas Lane, Columbus, O.

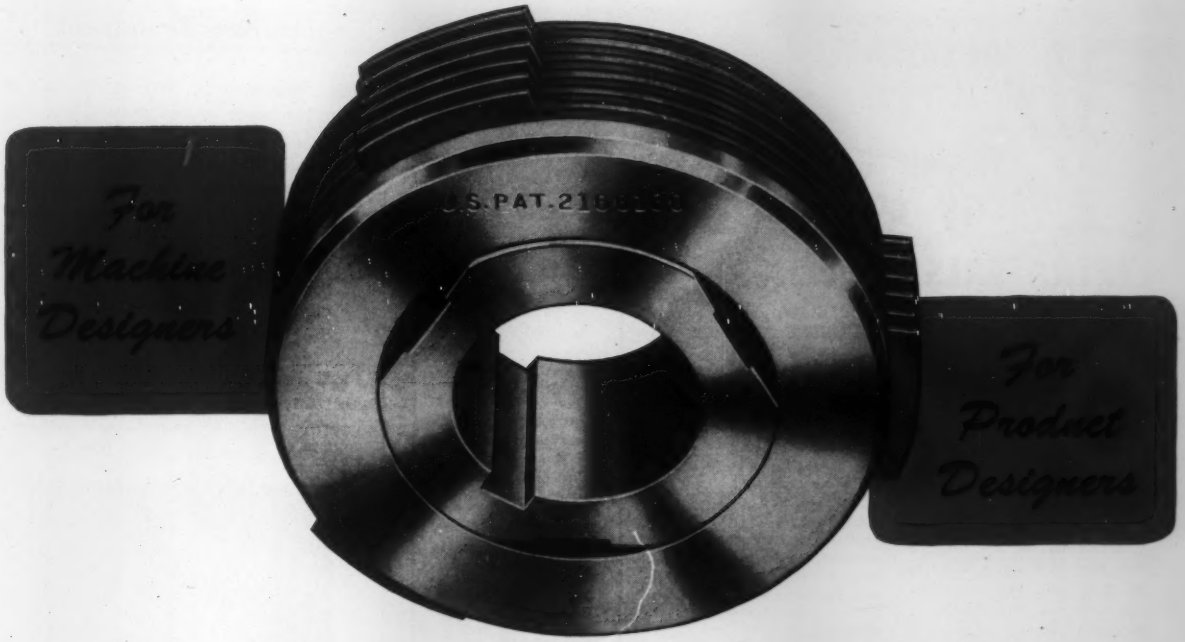
Circle 733 on page 19

Potentiometer

is also a millivolt source

Alinco Model P-55 universal potentiometer combines potentiometer and millivolt source in one instrument. Unit can be used with

any thermocouple, or to measure any potential from 0 to 55 mv. Dual input provides two sets of 55-way binding posts for checking two thermocouples, or one thermocouple against a standard. Thermometer is shock-mounted in lid,



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Patented Maxitorq Separator Springs that prevent drag, abrasion, and consequent heating in neutral . . . and the Maxitorq Locking Plate which locks all discs onto body . . . give you the outstanding features that are so highly favored by machine and product designers.

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The Disc-Pac fits Maxitorq standard Driving Rings in the event that you want to use them. As with the Maxitorq Clutch, all assembly, take-apart and adjustments are manual . . . no tools required. For further information, write Dept. MD-8.

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Circle 529 on page 19

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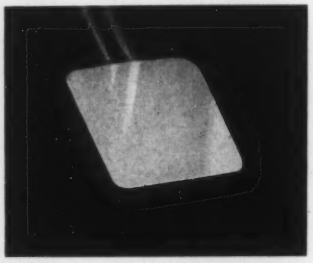
and instrument is available in aluminum or mahogany case. It is 4⅛ by 4½ by 7½ in. in size. **Allegany Instrument Co. Inc.,** 1091 Wills Mountain, Cumberland, Md.

Circle 734 on page 19

Resistance Thermometer

measures surface temperature

RdF Strapon resistance thermometer for surface temperature measurement is a moisture-resistant, portable, reusable and flexible in-



strument. Silastic overmold permits use in presence of radioactive fields, high humidity, water, alcohols, salts, oils, some acids, caustics and other substances that normally render temperature transducers ineffective. **Arthur C. Ruge Associates Inc.,** 733 Concord Ave., Cambridge, Mass.

Circle 735 on page 19

Tracing Cloth

has double water-repellent surface

No. 378WD Whitney double-surfaced water-repellent tracing cloth permits unchanging parts of a drawing to be drawn on one side of cloth while details subject to repeated revision can be drawn on other side. Erasures are made easily on detail side without removing information from the other side. Cloth is impervious to perspiration stains and water spotting, and can be cleaned with common solvents. It takes pencil lines to 9H and repeated erasures without surface damage. Material is available in all sheet sizes, and in 20-yard rolls with widths of 30, 36 and 42 in. **Charles Bruning Co. Inc.,** 4700 Montrose Ave., Chicago 41, Ill.

Circle 736 on page 19

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Circle 530 on page 19

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Engineering materials and processes are described in this book from the designer's viewpoint. Information is presented so that designers can select materials best suited for design with respect to processing, service life, first cost, maintenance requirements and function.

Principal manufacturing processes including metal forming and shaping, cutting, joining, finishing, inspection, assembly, and packaging are described and analyzed.

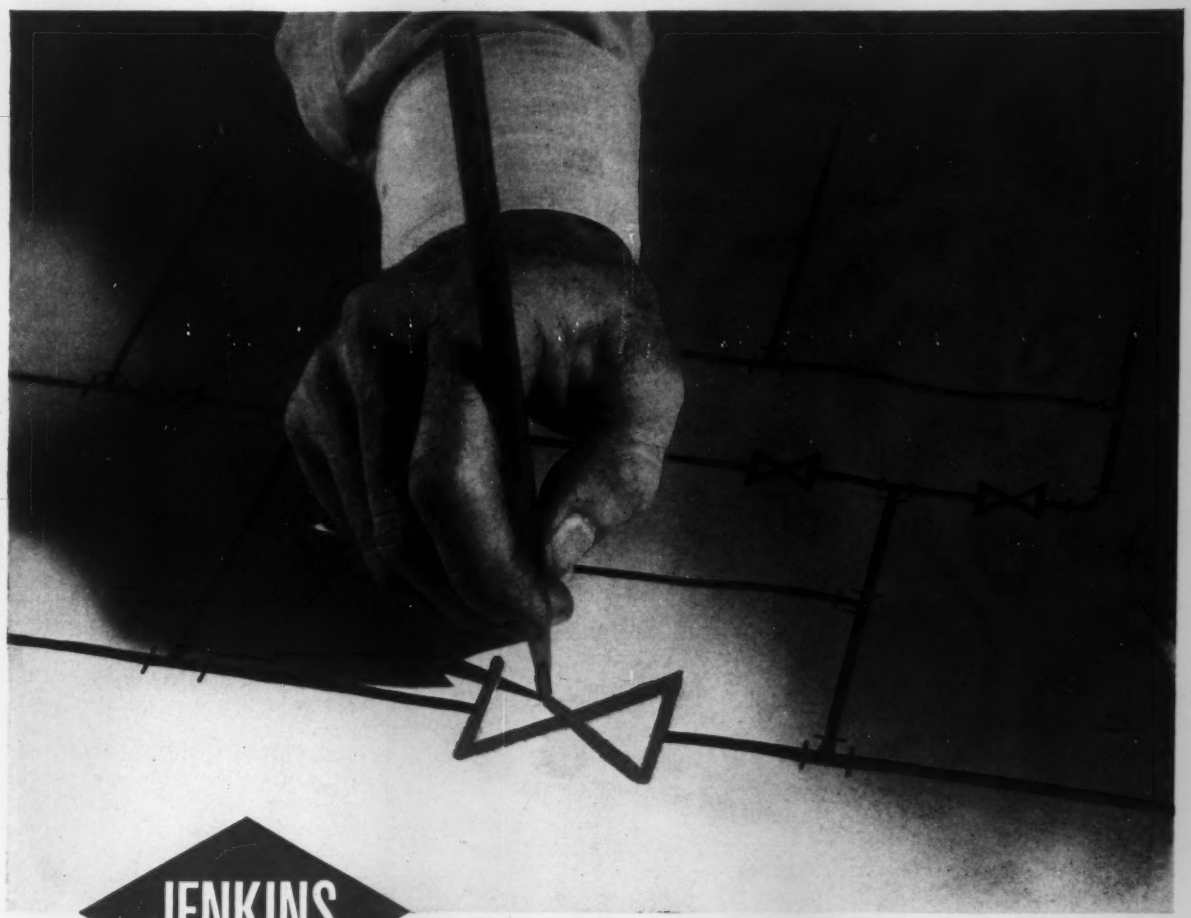
Past Examinations for Professional Engineer, 1957 Edition. *81 pages, 8½ by 11 in., paperbound; published by and available from John D. Constance, P. E., 625 Hudson Ter., Cliffside Park, N.J.; $2.00 per copy.*

This is a compilation of past examinations for Professional Engineer given by the New York State Board of Examiners, and covers years 1946 through 1957.

Three major parts include structural planning and design, basic engineering sciences, and engineering economics and practice.

Brittle Behavior of Engineering Structures. *By Earle R. Parker, Chairman, Div. of Mineral Technology, University of California; 323 pages, 6 by 9 in., clothbound; published by John Wiley & Sons Inc., 440 Fourth Ave., New York 16, N.Y.; available from* MACHINE DESIGN, *$6.00 postpaid.*

This book summarizes available information on brittle behavior of steel in engineering structures. It contains a discussion of theories and mechanism of failure, a review of test methods for evaluat-



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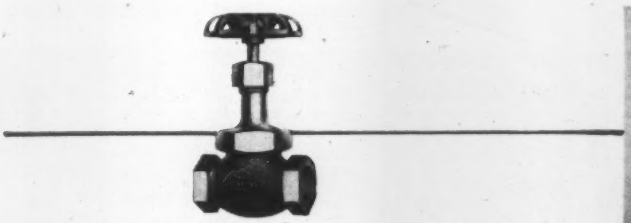

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Circle 531 on page 19

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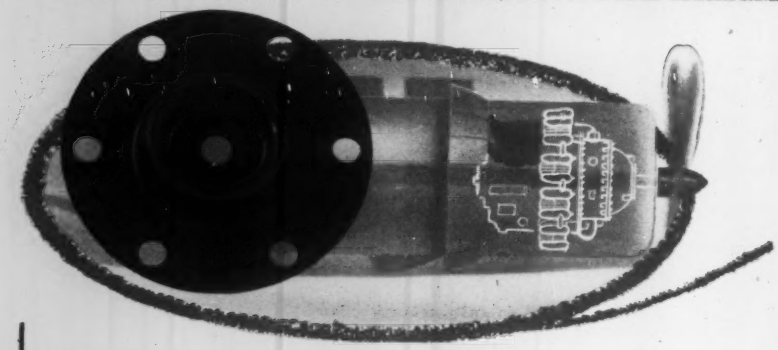

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ing relative brittleness, interpretations and summaries of test results, a discussion of effects of welding composition variations on notch toughness, and a report of service failures. It also offers a survey of fundamental properties and fracture theories.

Mechanics For Engineers. *By F. P. Beer, Professor of Mechanics, and E. R. Johnston Jr., Professor of Civil Engineering, both of Lehigh University; 672 pages, 6 by 9 in., clothbound; published by McGraw-Hill Book Co. Inc., 330 West 42nd St., New York 36, N. Y.; available from* MACHINE DESIGN, $8.00 *postpaid.*

This book covers necessary operations with forces, then applies the concept of equilibrium to problems involving particles. Practical situations are introduced early. Statics of rigid bodies is considered in both two and three dimensions.

In applications to bodies and structures, principal emphasis is on equilibrium. In dynamics, the three basic methods of analysis are first applied to problems involving only particles, so that their respective advantages may be clarified.

The concept of free-body diagrams is presented early and used throughout. Emphasis is placed on the idea of equivalent force systems and the use of "free-body diagram equations." This approach makes possible a clear presentation of the fundamental principles of statics and dynamics.

Practical Automation. *By L. R. Bittel, M. G. Melden, and R. S. Rice, Associate Editors, Factory Management and Maintenance; 376 pages, 8½ by 11 in., clothbound; published by McGraw-Hill Book Co. Inc., 330 West 42nd St., New York 36, N. Y.; available from* MACHINE DESIGN, $7.50 *postpaid.*

This book is a practical guide for installation and use of plant automation for increased productivity, lower operating costs, and improved safety and working conditions.

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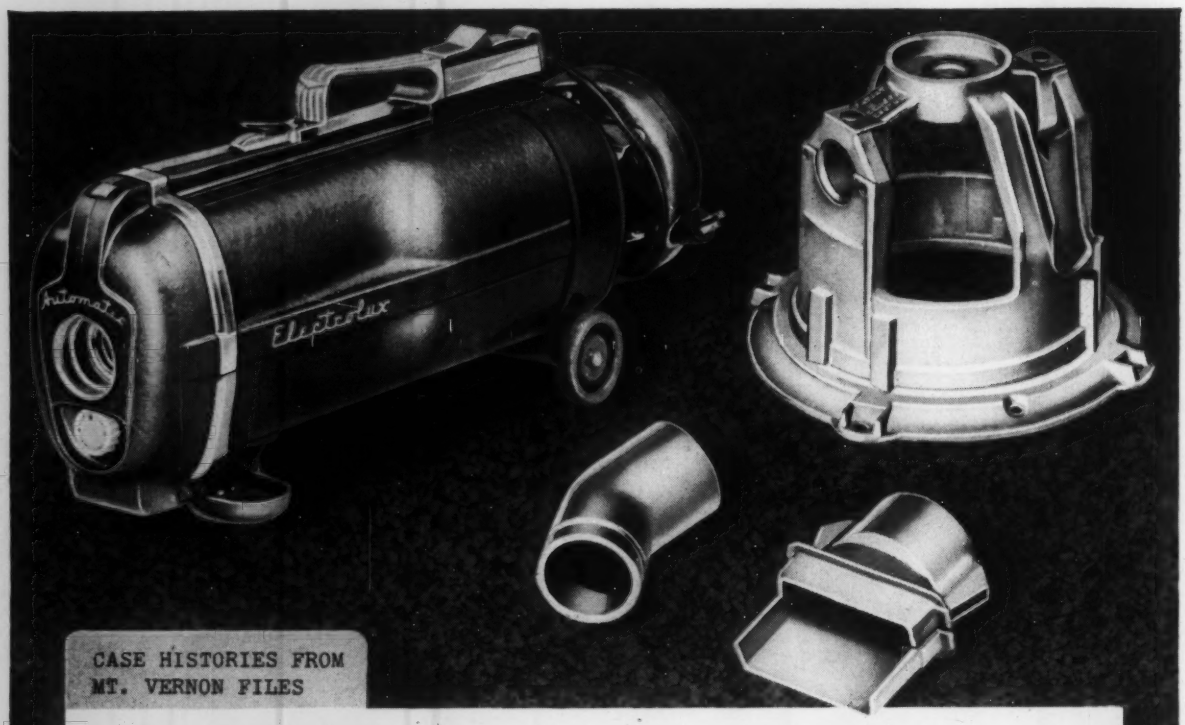

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are explained and illustrated. In addition, the book includes examples of installations from plants of all sizes in various industries, and demonstrates actual applications and methods.

It also demonstrates how to solve problems likely to be met in combining machines and equipment already in use, applying feedback control, solving new maintenance problems, and other practical aspects of automation.

Other topics are: automatic handling, processing, inspection, and communication; special problems relating to electrical, hydraulic, and other systems; and essential techniques, equipment, and materials for automation.

One Hundred Electronic Circuits. *By Milton H. Aronsen and Charles F. Kezer; 168 pages, 5½ by 8 in., paperbound; published by and available from Instruments Publishing Co. Inc.; 845 Ridge Ave., Pittsburgh 12, Pa.; $2.00 per copy.*

This book contains 100 circuits complete with detailed specifications and values for all circuit components.

Included are 15 power-supply circuits, 18 amplifier circuits, 15 oscillator and generator circuits, 20 pulse circuits, 17 test-instrument circuits, 3 alarm circuits, 3 phototube circuits, and 9 miscellaneous circuits (phase shifters, controllers, etc.).

The book also provides operating specifications which will enable circuit designers to modify existing circuits according to requirements.

Principles of nonlinear capacitors, magnetic amplifiers, transistors, phase-shifts, bridge operation, cold-cathode memory tubes, and other components are included.

Hydraulics Refresher for Professional Engineers License. *By John D. Constance, P.E.; 64 pages, 8½ by 11 in., paperbound; available from John D. Constance, P.E., 625 Hudson Terrace, Cliffside Park, N. J.; $3.00 per copy.*

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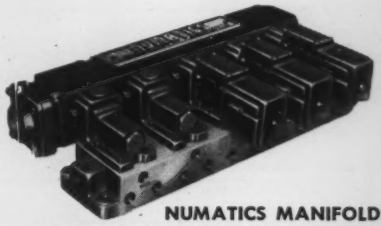

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problems, revision of material and presentation make this book suitable as a review for civil service examinations for engineering grades, power engineer examination, and practical engineering office problems.

Major sections include hydraulics, hydrodynamics, orifices, weirs, flow in pipes, flow in open channels, and centrifugal pumps.

Advanced Calculus. *By R. C. Creighton Buck, Professor of Mathematics, University of Wisconsin; 423 pages, 6 by 9 in., clothbound; published by McGraw-Hill Book Co. Inc., 330 West 42nd St., New York 36, N. Y.; available from* MACHINE DESIGN, $8.50 *postpaid.*

This book presents a systematic approach to the differential and integral calculus of functions and transformations and develops analytical techniques to apply to problems of mathematics.

Features include simultaneous discussion of functions of one and several variables, details of the double integral, elementary theory of Cartan's differential forms to simplify vector calculus, up-to-date treatment of curves, surfaces, and manifolds; and approximation.

New Standards

1956 Supplement to Book of ASTM Standards, Including Tentatives. 2250 *pages in seven parts, 6 by 9 in. paperbound; published by and available from American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa.;* $4.00 *per copy to nonmembers.*

Part 1, Ferrous Metals — contains 48 standards on steel pipe, tubes, fittings, castings, bolting materials, boiler plates and rivets, rails, rolled wheels and tires, chain, and cast and nodular iron.

Part 2, Nonferrous Metals — contains 60 standards on copper and copper base alloys, nickel and nickel base alloys, electrical resistance and related alloys, metal powders and products, die-cast metals and alloys, aluminum and aluminum alloys, magnesium and magnesium-base alloys, and metallic electrical conductors.

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Soils — contains 57 standards on cement, lime, gypsum, pipe and drain tile, refractories, ceramic whiteware, stones, mineral aggregates, concrete, bituminous materials for highway construction, waterproofing and roofing and soils.

Part 4, Paint, Woods and Wax Polishes — contains 78 standards on white pigments, drying oils, paint driers and thinners, shellac, varnish, and resinous materials, lacquer and lacquer materials, polishes, wood and wood preservatives, and acoustical materials.

Part 5, Fuels and Petroleum—contains 75 standards on measuring and sampling petroleum and petroleum products, crude petroleum, motor and aviation fuels, hydrocarbons, diesel fuels, distillate burner fuels, kerosene and illuminating oils, coal, industrial aromatics, and general testing methods.

Part 6, Rubber and Plastics—contains 71 standards on plastics, electrical insulating materials, rubber products, latex foam sponge and expanded cellular rubber, nonrigid plastics and electronics materials.

Part 7, Textiles and Soap—contains 34 standards on textile materials, detergents, paper and paper products, shipping containers, adhesives, water and atmospheric sampling tests.

Manufacturers' Publications

Handi-Book of Anti-Friction Bearings. *36 pages, 5½ by 8 in., paperbound; published by and available on letterhead request from Hoover Ball and Bearing Co., Ann Arbor, Mich.*

This book is intended as a reference for information about bearings and bearing applications. Major topics include bearing classification and selection, types, modifications, capacities, formulas, fits and lubrication. Bearing noises and causes of failure are also discussed.

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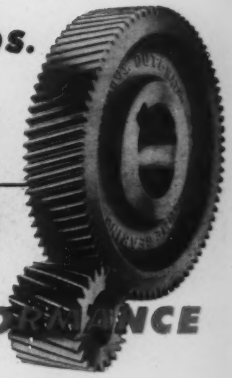

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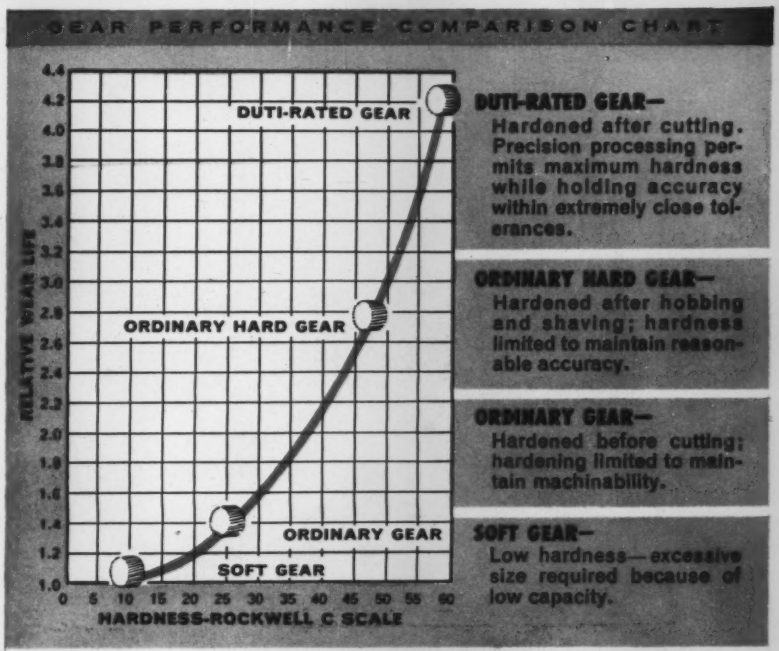

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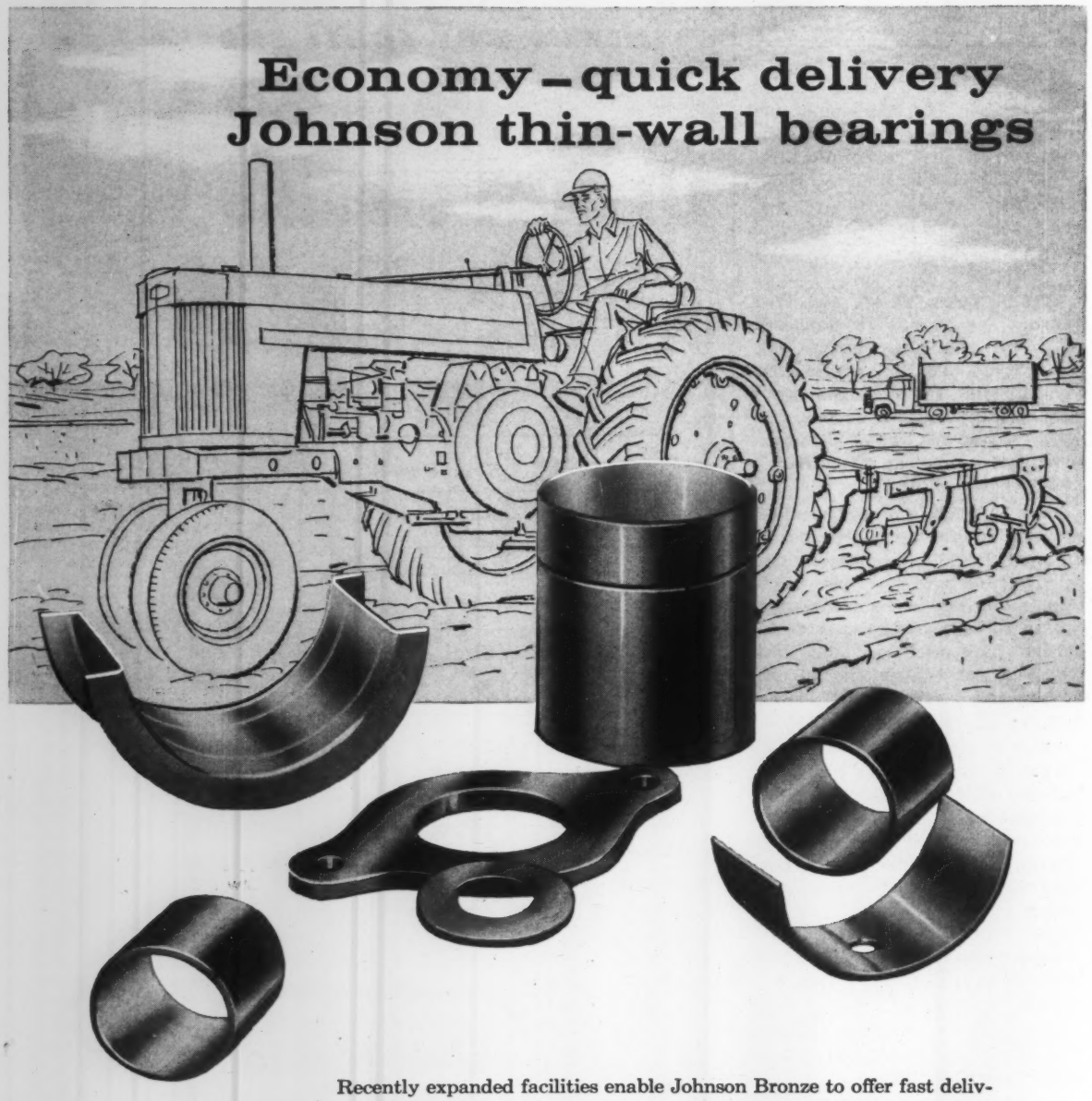
Circle 536 on page 19

Economy – quick delivery Johnson thin-wall bearings



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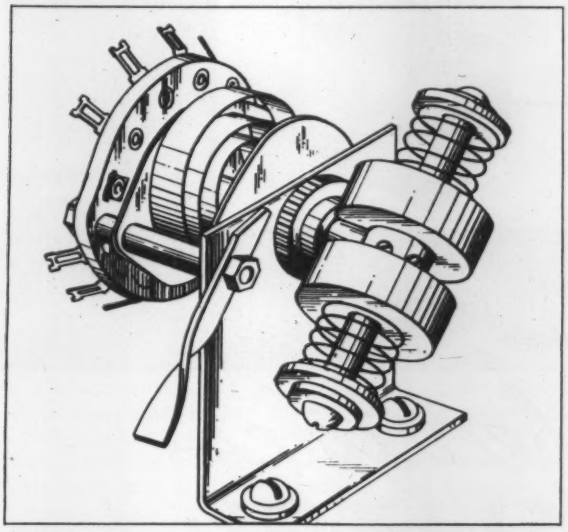
Circle 537 on page 19

NOTEWORTHY

Patents

Spring-Driven Intervalometer

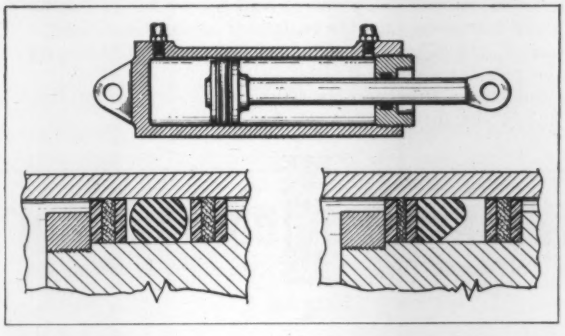
Sequential closing of multiple contacts is accomplished by a spring-driven intervalometer with easily modified time-interval setting. Powered by a clock spring, the unit incorporates a wafer-switch contact



assembly that shorts all remaining circuits when one circuit is closed. Time interval, which is held substantially constant by a fly-weight governor, can be modified by simply changing the tension of the fly-weight springs. Switch action begins when pawl-pinion ratchet is released. *Patent* 2,795,661 *assigned to U.S.A. by Leo L. Kielman.*

Sectional Fluid Seal

Grease-saturated wicks, sandwiched between rigid Teflon back-up rings, provide continuous lubrication to the O-ring in a sectional seal assembly. In the piston-actuator application shown here, left view represents O-ring configuration when hydraulic pres-



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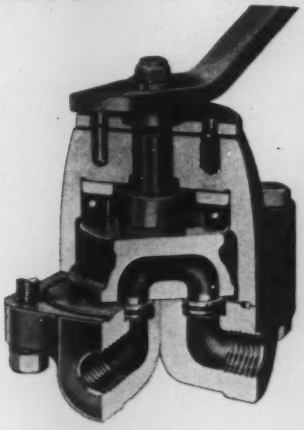

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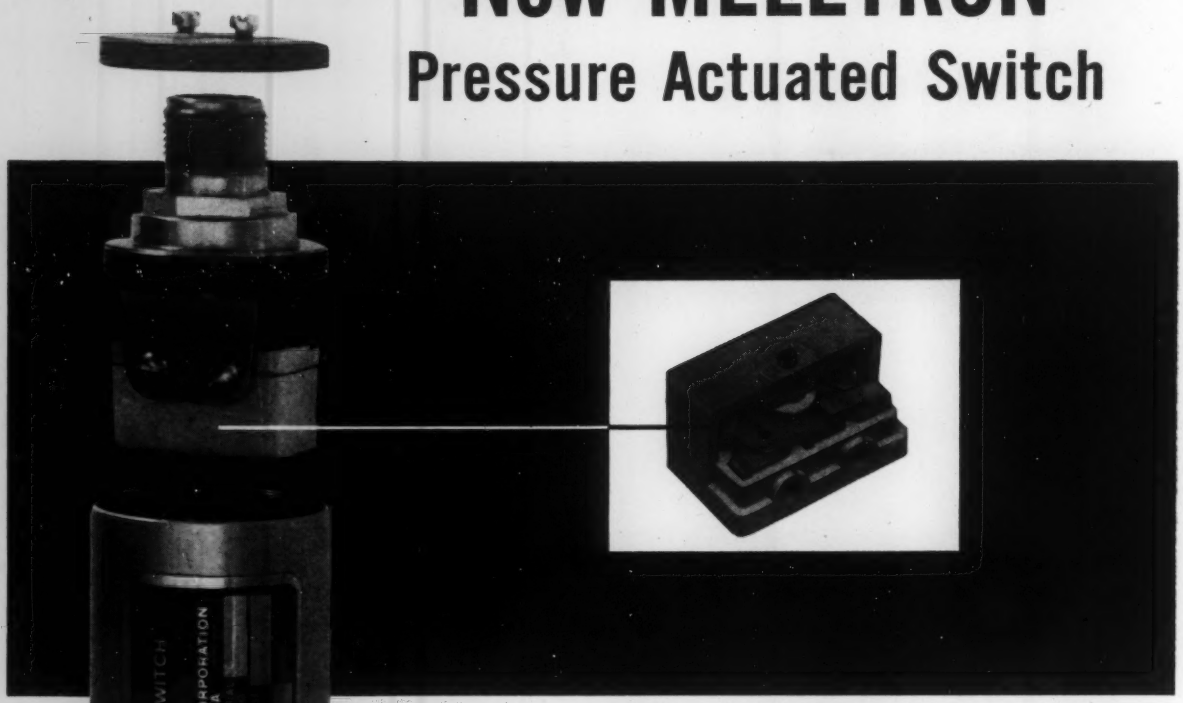
Pressure Actuated Switch



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Movement differential as well as operating and release forces can be precisely adjusted and set to meet a wide variety of application requirements. Once calibrated, the Klixon Sine Switch precisely maintains its operating characteristics throughout its life.

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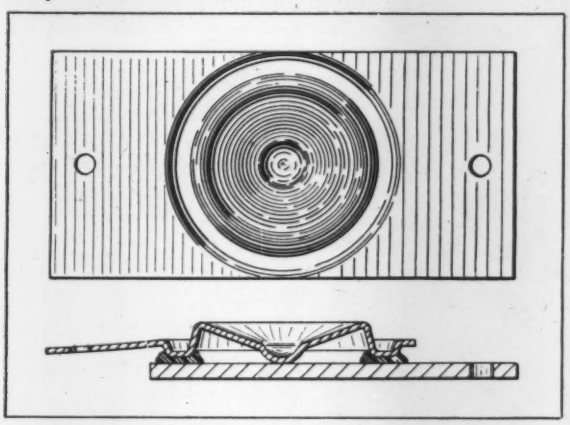
Circle 539 on page 19

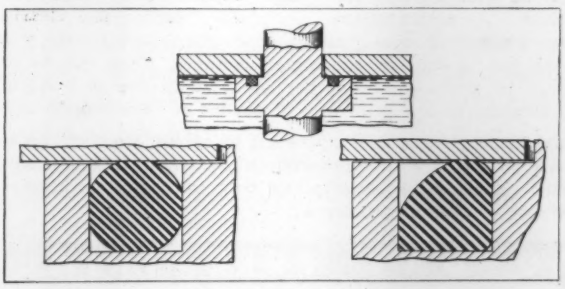
sure difference across piston and seal is zero. When high pressure is applied to the piston rod-end side, the piston moves left and the O-ring deforms as in the lower left view. Pressure of O-ring against the back-up plates then squeezes the wick, providing a lubricant film between cylinder and O-ring. *Patent 2,797,971 assigned to Cleveland Pneumatic Tool Co. by Raymond E. Greenough.*

Snap-Action Switch or Thermostat



Expansion of fluid sealed between a die-formed diaphragm and a flat backing plate provides the actuating force in a simple snap-action switch. When unit is used as an overload switch, heat causing fluid expansion is generated by current flow through diaphragm apex and backing plate. Ambient heat similarly actuates the switch in a thermostatic-control application. *Patent 2,798,130 assigned to Cutler-Hammer Inc. by Irvin W. Cox.*

Low-Friction Seal



Nearly constant sealing pressure is maintained by a low-friction seal utilizing a conventional O-ring. Positioned in a channel with depth and width of approximately 95 per cent of ring-section diameter, the O-ring assumes the configuration at lower left when subjected to normal fluid pressures. With increasing pressure, O-ring deforms as in right-hand sketch. Resulting combination of increased unit pressure and reduced contact area gives almost constant total seal pressure and ensures low friction torque over the operating range of the seal. *Patent 2,795,441 assigned to U.S.A. by Lynford W. Gilbert and Wayne B. Loyd.*

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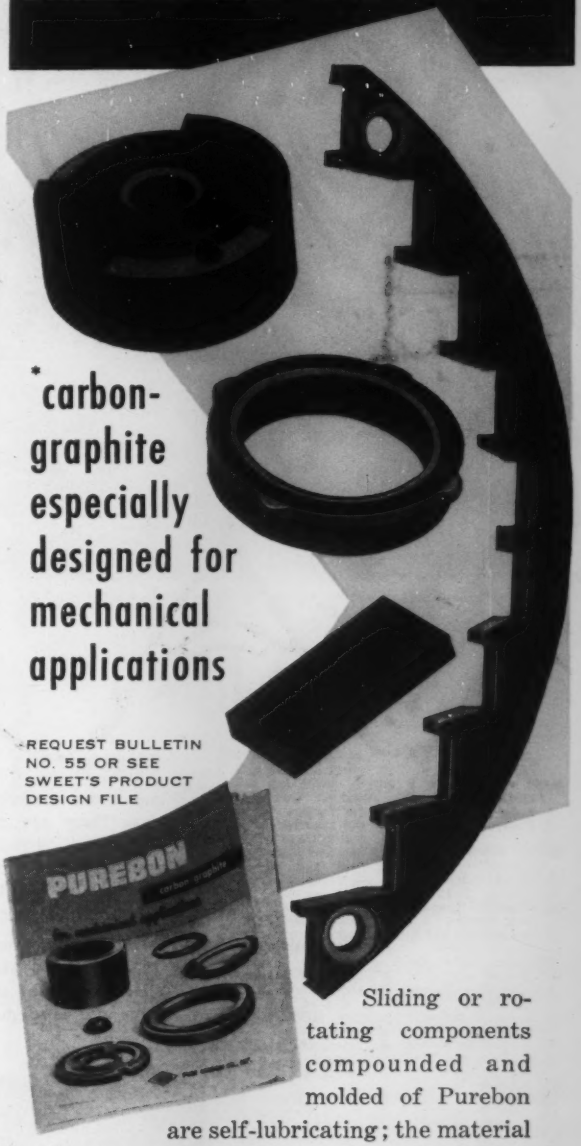

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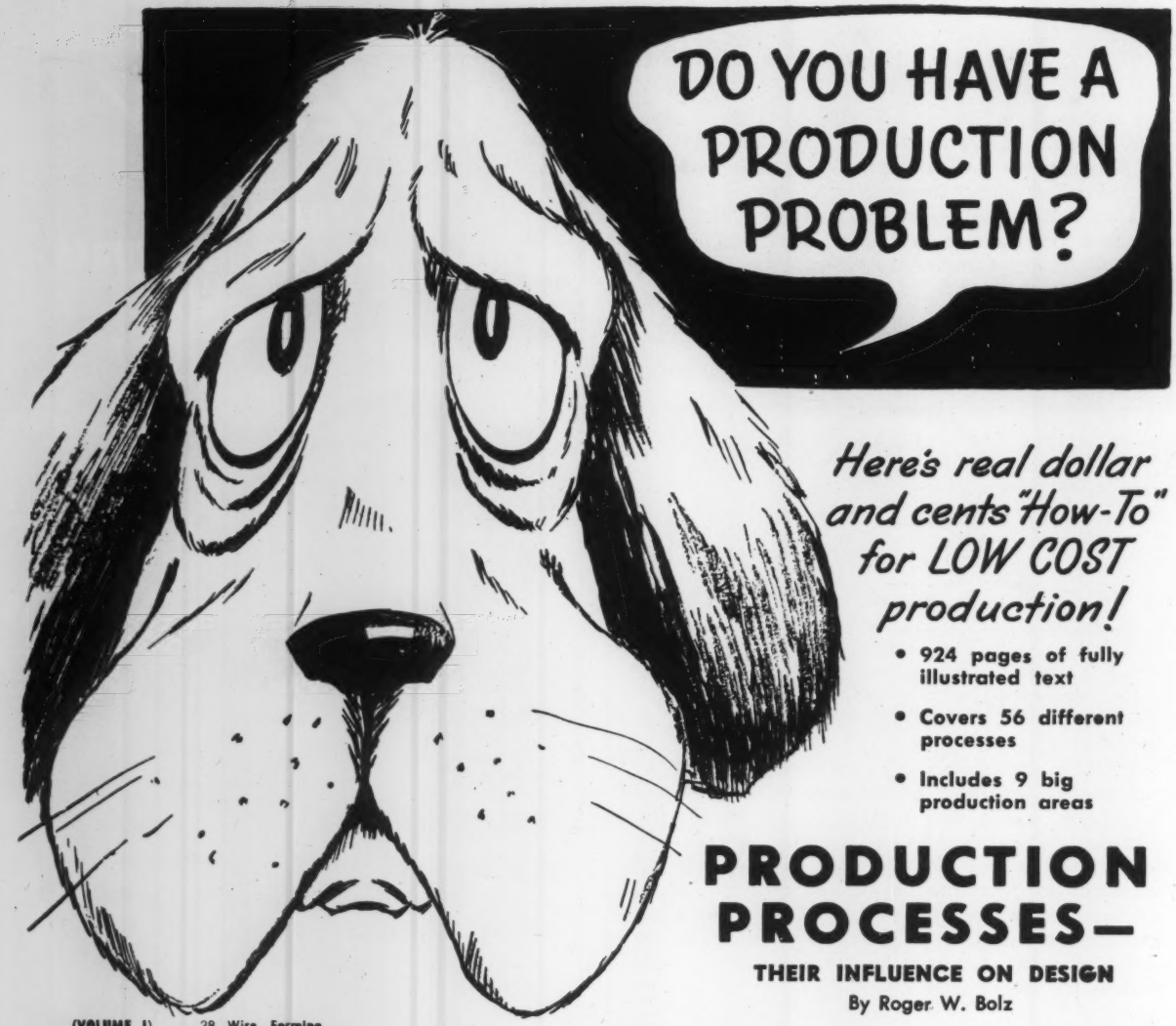

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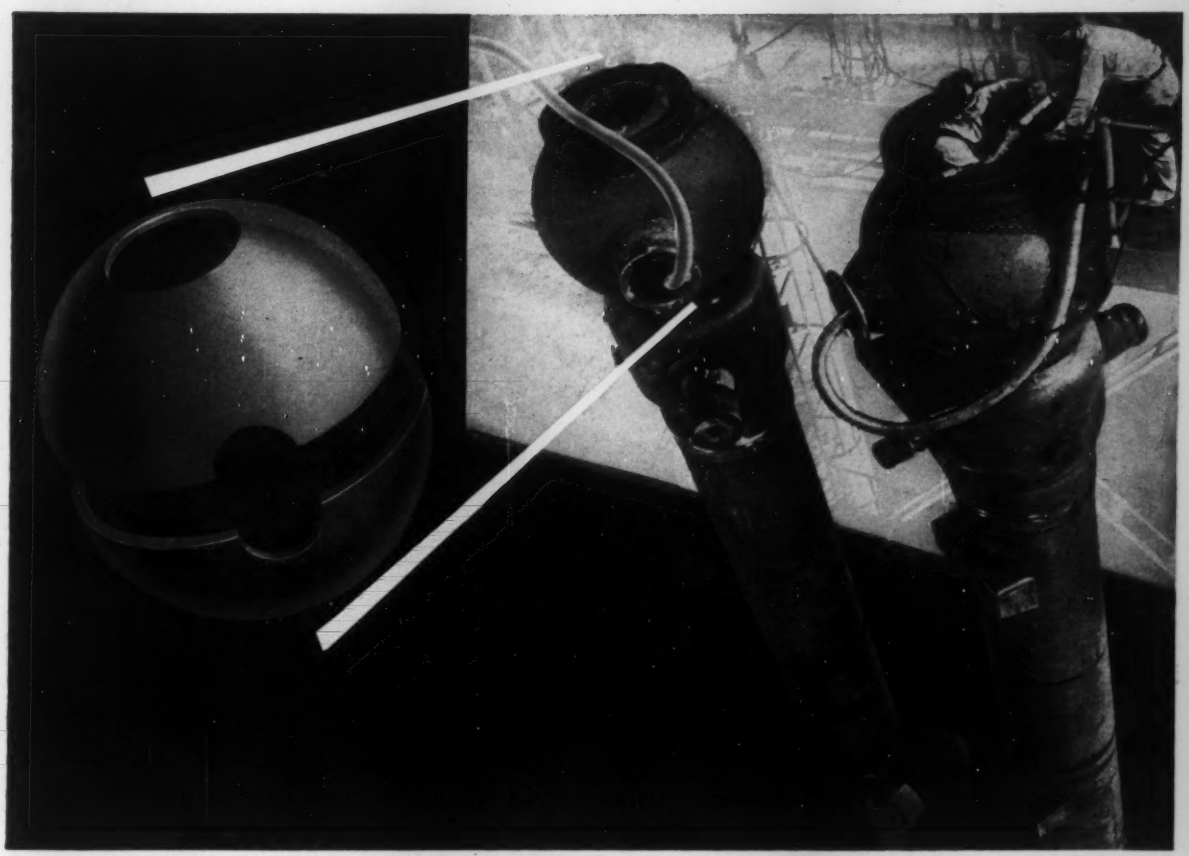

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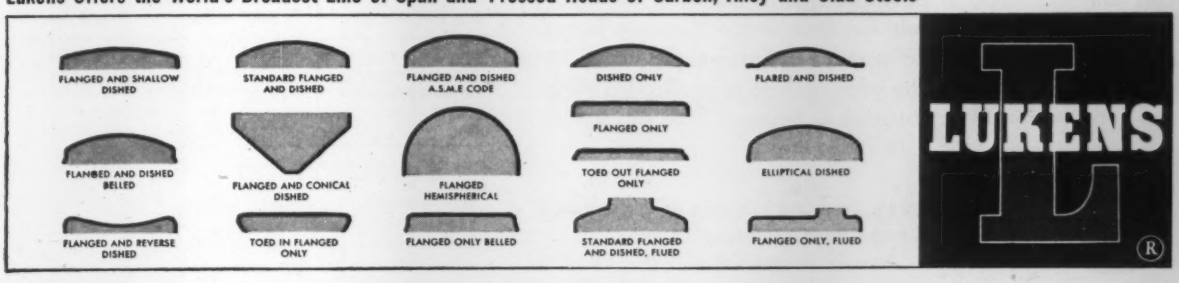

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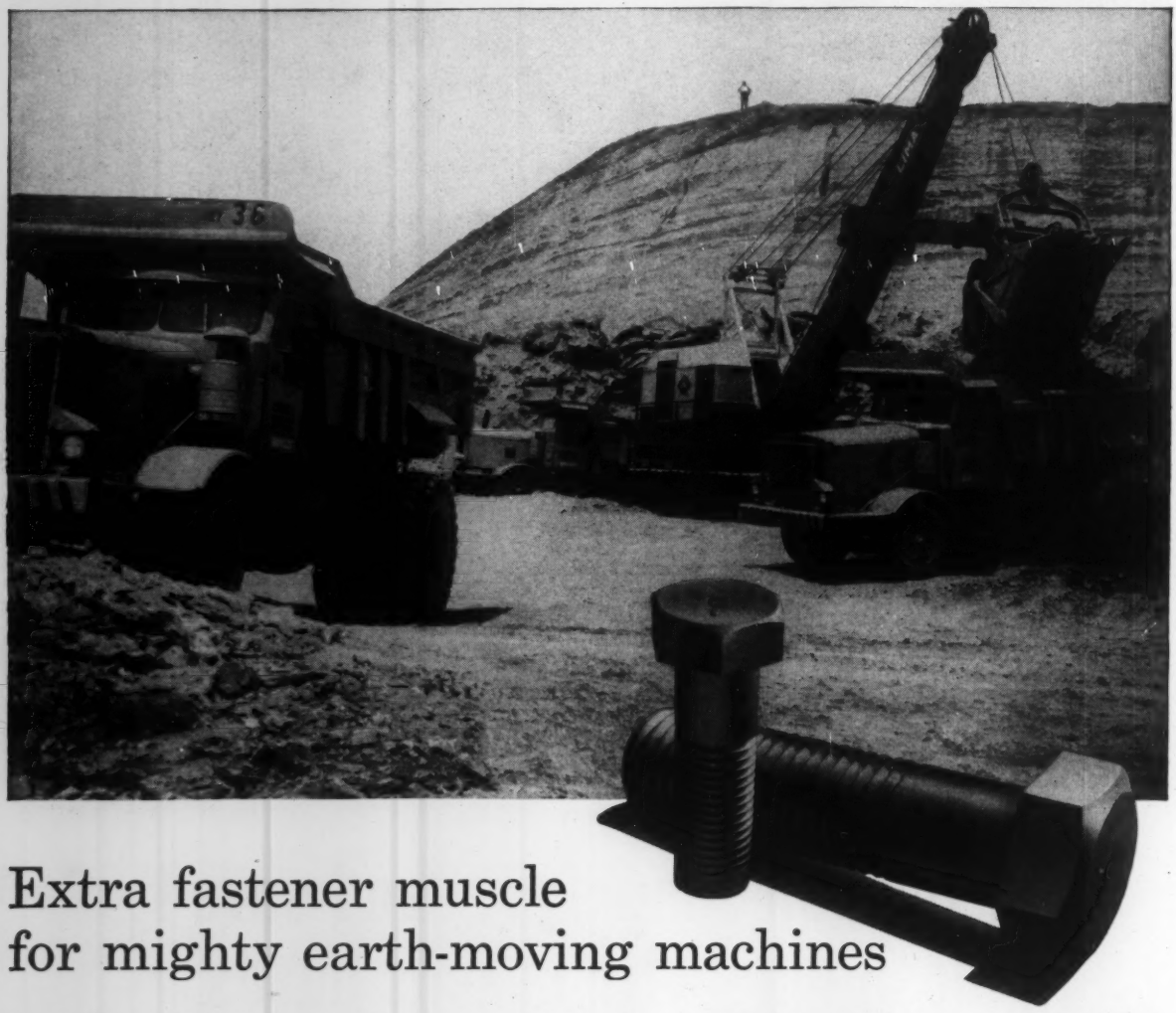

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Quenched & Tempered (SAE Grade 5)	Up to 3/4 incl. Over 3/4 to 1 incl. Over 1 to 1 1/2 incl.	120,000 min. 115,000 min. 105,000 min.
Quenched & Tempered (SAE Grade 6)	Up to 3/8 incl. Over 3/8 to 3/4 incl.	140,000 min. 133,000 min.
Alloy (SAE Grade 7)	Up to 1 1/2 incl.	130,000 min.
Alloy (SAE Grade 8)	Up to 1 1/2 incl.	150,000 min.
Bright	Over 1 1/2 to 2 1/2 incl.	55,000 min.
Quenched & Tempered	Over 1 1/2 to 2 1/2 incl.	90,000 min.
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Circle 542 on page 19

Q

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Production Bronze Castings?

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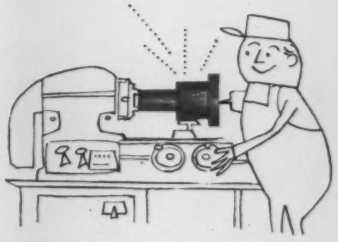
Here?



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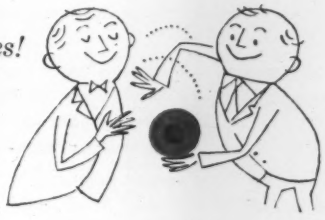
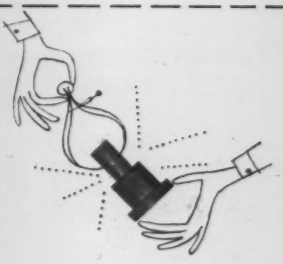
Smoother cast surfaces!
Often, smooth enough to use as is.



Closer tolerances!
Most castings held to ±.015 — favorable shapes, ±.010.



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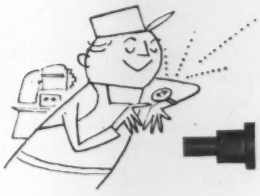
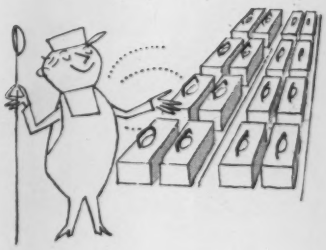
In some cases, finishing operations are eliminated.



Lower cost!
High-speed, semi-automatic mold production means foundry economy.



AMPCO®

THE METAL WITHOUT AN EQUAL

AMPCO METAL, INC.
Milwaukee 46, Wisconsin
West Coast Plant:
Burbank, California
One-source service from raw material to finished product

FREE BULLETIN TELLS MORE. TEAR OUT COUPON AND MAIL TODAY!

AMPCO METAL, INC.
Dept. MD-8, Milwaukee 46, Wisconsin
Send me Bulletin G-36 on shell moldings; also information on other Ampco products I have checked.

Name.....
Title.....
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- ☐ Specifications of Ampco Metal
- ☐ Ampco Wrought Products
- ☐ Ampco Stock Raw Materials
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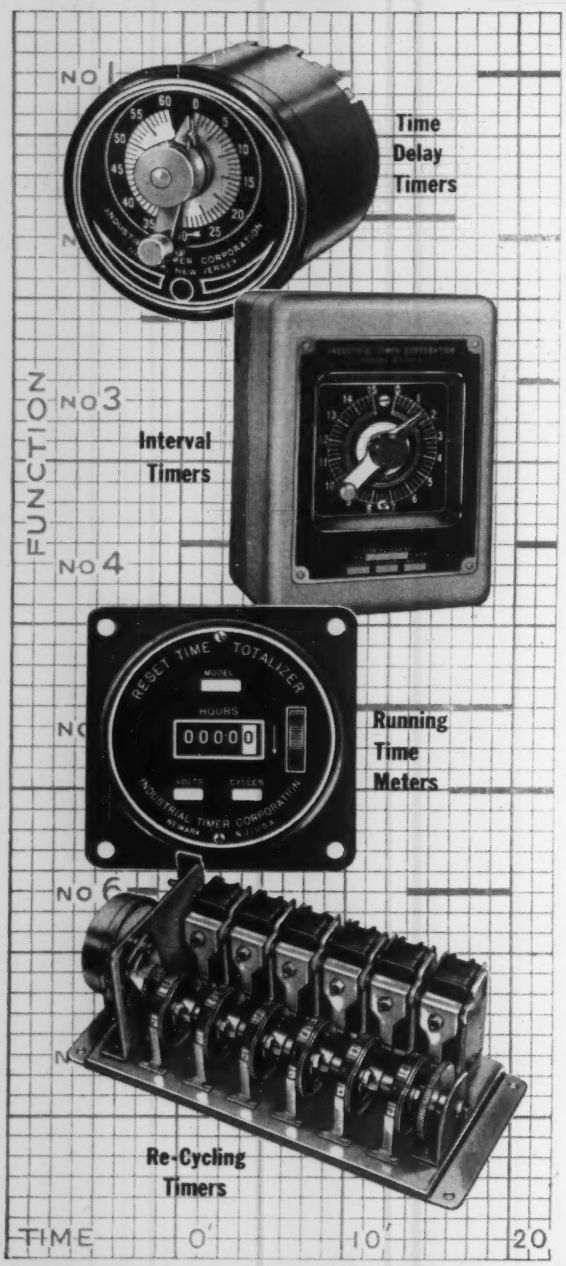
- ☐ Ampco-Weld Resistance Welding Electrodes

D-61

Need a "SPECIAL" TIMER ...need a "STANDARD"?



Here's why WE can give you the fastest service

When you want a timer, you want one that fits your needs 100% — and you want it *fast*. Get in touch with Industrial and you'll get both. Because:

In our 20 years of experience, we have developed over a *thousand combinations* from our 17 basic types, to meet the widely varying needs of our customers. Therefore — many jobs that would seem to require a "special" timer are in fact a "standard" timer with us. Here is one tremendous saving of time for you.

When you *do* need a special timer, this same wealth of experience goes to work for you at once to design it. Our Engineering Department not only originates new designs, but also develops modifications for that purpose. That's why requests for special timers can be filled without delay.

Each method — designing for a standard timer or for a special timer — has its advantages. Designing for an already available timer means lower costs, faster service, simplified replacements.

Designing for a special timer has its advantages too It means you'll fulfill your needs 100% — no need to limit your designing horizons. Either way — standard or special — you'll get the timer you want most promptly from Industrial.

Or perhaps you need quick service on timers for automatic controls. Here too Industrial Timer is your first source of supply. For in this field Industrial has a big head start. True, each automatic control job is a bit different from the rest. But the record shows that our years of timer experience has given us the special knowledge it takes to give you the right answers in near-record time.

So, for the utmost in all-round timer service, it's Industrial that offers you this outstanding combination: deliveries "Immediate on Standards . . . First on Specials." Plus the experience of one of the foremost group of timer engineers in the nation.

Timers that Control the Pulse Beat of Industry

INDUSTRIAL TIMER CORPORATION

1413 McCARTER HIGHWAY, NEWARK 4, N. J.

Circle 544 on page 19

R B&W FASTENER BRIEFS

RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY

Technical-ities
By John S. Davey

Tighten bolts to yield strength?

Actually, it is safer to "overtighten" than to undertighten. The following explains why.

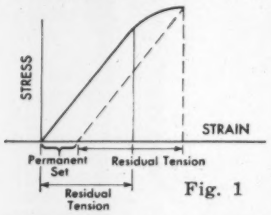


Fig. 1

Up to yield point, the strain in a bolt is proportional to stress. *Beyond* the elastic limit, the bolt goes into its "plastic range". Some permanent stretch takes place. (Fig. 1). Yet while the bolt will not return to original length, note that *residual tension* is fully maintained. And remember, it's *this* force that keeps a bolt tight, determines joint strength.

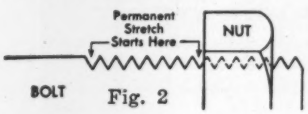
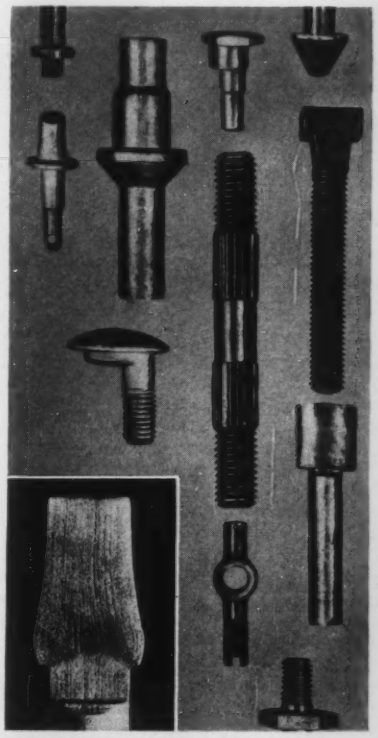


Fig. 2

The permanent set starts at section with highest unit stress —which is at the unengaged threads (Fig. 2). Ultimately, this throws thread pitch off and nut locks, subjecting bolt to torsion (rather than further tightening). This force disappears with wrench-removal. Thus, a bolt can even be torqued well into its plastic range if it won't be reused or need adjustment.

Cold facts on cold headed fasteners



RB&W cold heading machines have forced metal to flow into this typical variety of shaped pieces—just a handful of thousands of different cold headed shapes produced by RB&W to specification. The upset can be at any point, and the shape need not be symmetrical. The continuous, symmetrical flow lines (inset) make metal stronger.

NO ATTEMPT to simplify, improve or economize on fastening is complete without a good look at your screw machine parts, forgings, and certain assemblies that can be reduced to one piece.

You would be surprised at what an expert can produce on cold headers with complete uniformity. Cold heading produces in one piece parts that would otherwise be two or more.

BETTER FLOW LINES

Just as it does with standard fasteners, cold heading makes possible a higher quality, stronger product at high speed and low cost. Properly done, the operation upsets metal along its own axis in continuous flow lines without folds. Stress patterns are better. Fasteners and parts gain greater shear, impact and fatigue strength.

Long a specialist in cold headed fasteners, RB&W offers its experience to designers and production men who want to know whether cold heading is feasible for specific mechanical shapes. If it proves to be so, RB&W facilities can handle your volume needs. Contact Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, New York.

Plants at: Port Chester, N. Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional sales offices at: Ardmore (Phila.), Pa.; Pittsburgh; Detroit; Chicago; Dallas; San Francisco.

Spin-Lock® Screws solve assembly problem

The designer specified countersunk-head screws to be used in a particular casting. The production man had to stake these in to anchor them. But this meant extra operation, made screw removal damaging and difficult.

The answer was found in Spin-Lock screws. These have hardened "ratchet-action" teeth that bite in when tightened, take 20% more torque to loosen than to tighten, can be reused. Send for Bulletin.

Spin-Lock "tooth" about to bite in. Head meets seat when fully tightened.

Circle 545 on page 19

It's the **Original Equipment* idea . . . which simply means that, when you're figuring on electrical or mechanical counters in any new product, it pays to *design them in, when you begin.*

For then Veeder-Root quite likely can save you time and money by adapting or modifying a *standard* counter to your needs, instead of a special which you might specify on your own. This solves the counter problem . . . and saves you time in engineering, purchasing and assembly.

What's more, you give your product new sales-advantages: Direct-reading digits, instead of hard-to-read dials and verniers . . . instant remote indication if needed . . . up-to-the-minute performance records that serve as a basis for production-*Count*rol, and as proof of your performance guarantee. So don't let counters take a back seat in your new-product plans. *Design them in, when you begin* . . . it pays in many ways. Do you have the newest Veeder-Root Catalog? Write

Series 1205
Reset Magnetic Counter

Everyone Can Count on Veeder-Root

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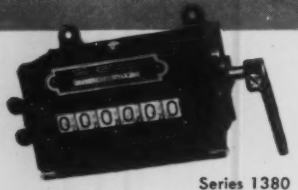
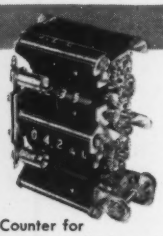
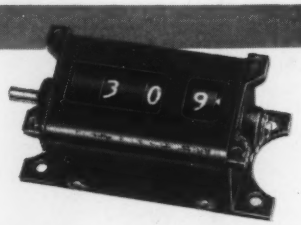


Series 1380
Box-Type Counter (Ratchet, Revolution, or Geared)



4-bank Counter for Radio Transmission Equipment



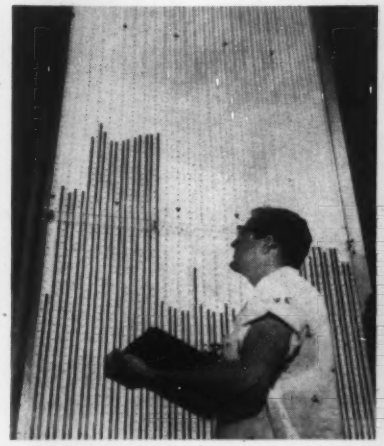
360-degree Bearing Counter

Circle 546 on page 19

THIS IS GLASS

a bulletin of practical new ideas from Corning

Pressures of the jet age



To take pressure readings from a jet engine sealed in a test cell, this man is using what may be the Gargantua of all manometers.

A number of these mammoth manometers (each stands better than *2 times as tall* as the average male) are used by Aro, Inc., operating contractor for the U. S. Air Force, Arnold Engineering Development Center, a collection of men and machines devoted to probing matters related to *supersonic* propulsion.

Trimount Instrument Company of Chicago makes these king-sized instruments, the main component of which is glass tubing.

This tubing is made from a PYREX brand glass. And like all items carrying the PYREX trademark, the tubing comes from Corning.

Here's why, according to the people at Trimount, they "take from" Corning for their tubing needs:

"We have found through years of experience that PYREX brand tubing is the finest for our requirements. Corning draws it to our specifications. For uniformity and extremely close tolerances required in our instruments, as well as strength and rigidity under high pressures, we specify closely held I.D. and O.D. tolerances. Also, the lengths required are important as we prefer not to use welded glass tubing . . ."

Such praise seems ample evidence that turning to Corning for glass components is sound practice from both an engineering and profit standpoint.

Thusly, an invitation to consider and investigate at your convenience. Outline your needs and we'll put our people versed in your field to work.

Or, peruse at leisure a recently issued book called "This Is Glass." It's filled with facts and pictures about glass at work in products and processes. Free.

Profitable pursuits from pipe dreams

Pipe dreams being of an illusory and mostly impractical nature, we offer instead some *dream pipe*.

Having need for more precise terms, those in our office who write orders call this dream stuff PYREX brand glass pipe.

Admittedly, this mundane phrasing tells little about the many talents of such pipe.

For example, it is eminently practical for *unusual* plumbing tasks, being equally at home handling waste acids of a corrosive nature or carrying milk from cow to bottle in modern dairy processing setups.

Immune to corrosive attack from most materials, PYREX brand glass pipe is easily installed, carries waste acids safely and economically.

Longevity is one of many trump cards you'll hold with a handful (figurative) of PYREX pipe. Like? An actuarial-minded chap once estimated that a section of pipe *will last some 203 years on a steady diet of hydrochloric acid*.

Equally valuable is the fact that you can keep constant visual surveillance over what's being piped. If plug-ups occur, you can see where they are and get at them easily.

Also yours with any item made from PYREX brand glass No. 7740 is *ruggedness* from the standpoint of thermal shock. With a coefficient of expansion of 32.5 x 10^{-7}, you can safely use this glass for high heat environments and/or where abrupt temperature changes are common.

Physical strength is also built in. Example: In a southern paper mill there's a 400 ft. installation of 3" (O.D.) PYREX pipe handling a *mercury amalgam*. Obviously, knowing men would never trust such an assignment to any material suspect of being *frangible*.

There's a lot more about PYREX glass pipe in Bulletin EA-1. There's a lot more about the PYREX brand and other glasses in Bulletin B-83. Glad to send you either or both.

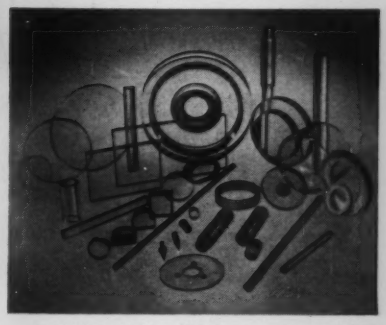
Close finish

During World War II considerable effort and experimentation were devoted to precision finishing for glass.

Since then, little has been said but quite a lot done in this field. For example, Corning makes for one customer the impeller, housings, and bushings for *an almost-all-glass pump*.

Made from PYREX brand glass No. 7740, these glass pump parts are precision ground and finished to terrifically tight tolerances.

Some of the other shapes and forms readily available with precision finishes are shown in this picture.



And this table will give you some idea of the operations and tolerances on tap at Corning.

Operation	Tolerances (inches)
Flat grinding and polishing	±.0005
O.D. grinding	±.0002
Internal grind, Step grooves, Angles and Tapers	±.0005
Circular Holes	±.005
Rectangles, Squares, etc.	±.001

Tubing, cylinders, rod, ground and polished discs and rectangles . . . these and many, many other glass forms await your investigation.

If you have some *tight* problem already at hand, brief us and we'll advise on the practicability of supplying you with a glass product to do the job.

Corning means research in Glass

CORNING GLASS WORKS, 52-8 Crystal Street, Corning, N. Y.

Please send me the following material: "This Is Glass" ☐; EA-1—"PYREX brand Glass Pipe in the Process Industries" ☐; B-83—"Properties of Selected Commercial Glasses" ☐.

Name_____ Title_____

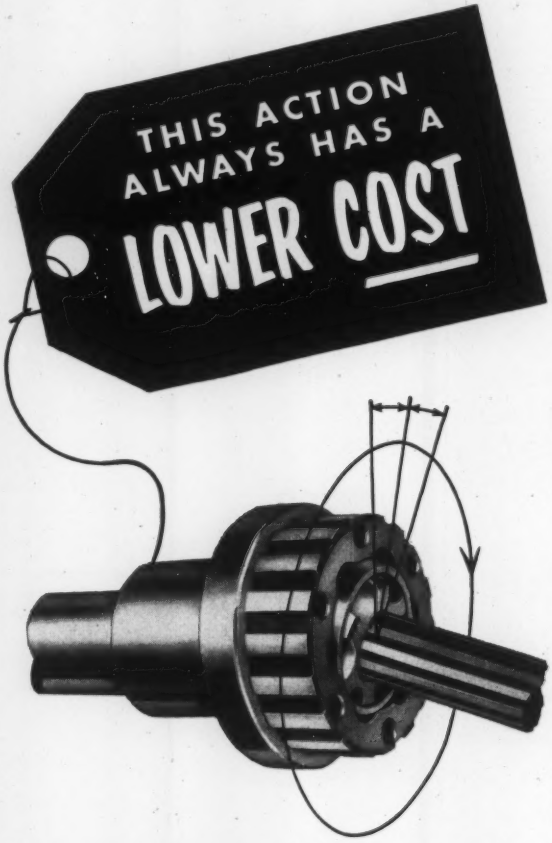
Company_____

Street_____

City_____ Zone_____ State_____

Circle 547 on page 19

Old-fashioned pin or slipper-type joints speed up, slow down twice during one revolution. This delivers rough "rock and roll" torque which results in greater vibration and wear. They must employ clumsy additional mechanisms to compensate for their unbalanced action at extreme angles.*



Rzeppa Joints *always* transmit smooth "full power" torque at angles as much as 35°! Ball bearings—located in a plane bisecting the angle between driving and driven members—deliver smooth rotation, eliminating wear and vibration. Constant velocity means longer joint and shaft life, too.*

57A

RZEPPA

SHEPPA

CONSTANT VELOCITY UNIVERSAL JOINTS

The Gear Grinding Machine Company

3937 CHRISTOPHER, DETROIT 11, MICHIGAN

MANUFACTURERS OF: FULLY AUTOMATIC GEAR GRINDING MACHINES
DETROIT SCREWMATIC 750 SINGLE SPINDLE SCREW MACHINES

*HOW RZEPPA'S CONSTANT VELOCITY SAVES YOU MONEY. If a universal joint operates with less friction it wears longer; if it has a higher capacity it can produce more. Through the principle of constant velocity—shown above—Rzeppa delivers these cost-savings that are impossible with designs of lower price.

Send us a dimensional sketch along with peak horsepower, operating angles and R.P.Ms. Our engineers will assist in making a proper joint recommendation. WRITE FOR LATEST BROCHURE.

Circle 548 on page 19

ENGINEERING BULLETIN

ON MICRO-BEARINGS

Miniature Instrument Ball Bearings

NEW HAMPSHIRE BALL BEARINGS, INC.

PETERBOROUGH 1, NEW HAMPSHIRE

Subject: **FACTORS TO CONSIDER IN MINIATURE BEARING APPLICATION**

TYPES OF BEARING

The Retainer Bearing fitted with the one-piece crown retainer is well suited for the great majority of instrument applications. Even ball spacing produces good performance at low-moderate speeds, and it can also handle radial or thrust loads. Improved fabricating techniques result in crown retainers being specified for low-torque requirements.

Phenolic Retainers machined from phenolic plastic allow higher speeds and also provide some retention of lubricant. This retainer is used with angular contact bearings where one land is ground away from the inner or outer ring to permit bearing assembly. Such a design permits thrust *only* in the direction of the side having the full land.

CROWN

PHENOLIC

The Full Bearing has a full complement of balls. Filling notches are ground on one side of each ring to allow assembly. This type is steadily being replaced by retainer bearings which cost less to manufacture and assemble. It has an advantage for certain applications requiring maximum radial load capacity, but is unable to handle thrust loads because of possible interference between the balls and filling notches. Contact between the balls creates friction which makes the full bearing unsuitable for low torque or high speed applications.

MATERIALS

Stainless Steel's anti-corrosive properties have made it first choice for bearings used in precision instruments, and it has become one of the standard materials for this purpose. It can be ground and finished to a high degree of precision.

Chrome Steel should only be specified when bearings must operate at critical limits of capacity, a condition not often encountered in instruments. It has a somewhat higher load rating than stainless steel but is subject to rapid corrosion if not protected during handling and use.

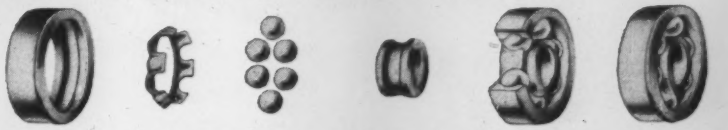
Beryllium Copper should be restricted to applications which definitely require non-magnetic properties in the bearings. All components of the bearing are fabricated from this material. If non-magnetic properties are not required, stainless steel is a better selection.

LOAD RATINGS

A miniature bearing is seldom operated at or near its rated load capacity. However, the designer must have sufficient information to assure intelligent selection. The load ratings presented in the New Hampshire Ball Bearings, Inc. catalog tables are based on standards established by the AFBMA after extensive studies and tests.

Dynamic load ratings apply to bearings that are rotating. Time-consuming calculations can be avoided by making use of the C factor shown in our catalog.

Static load ratings apply to bearings at rest. Since this exists in relatively few cases, static load rating is not usually given much emphasis. Formulae have been developed, however, and the need for this information is increasing, — primarily for units subjected to shock loading.



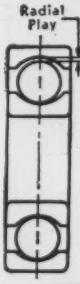
Retainer Bearing — Exploded and Assembled Views

Retainer Bearing — Flanged and Shielded

RADIAL AND AXIAL PLAY

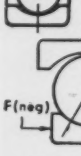
Radial play is the displacement of one ring with respect to the other along the *diameter* of the bearing.

It is important in the successful application of precision bearings and should be specified in orders. A range of .0002" to .0005" is satisfactory for most applications but tighter or looser clearances may be required. The minimum clearance should be .0001" and the total spread from min. to max. should be at least .0002".



Radial Play — Maximum distance one race may move diametrically with respect to the other without the application of measurable force when both races lie in the same plane.

Axial play is the displacement of one ring with respect to the other along the bearing axis. It is specified only when axial positioning of the shaft must be held within certain limits. Radial and axial play are mutually dependent factors and the former is the one usually specified.

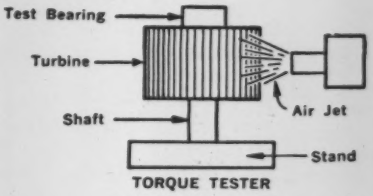


Axial Play — The maximum relative axial movement of inner race with respect to the outer, when both races are coaxially centered, without the application of measurable force.

TORQUE TESTS

Sensitive instruments require bearings with minimum inherent friction. Starting, or breakaway, torque is most often used to define limits. This is the force necessary to induce rotation from standstill under clearly established conditions of mounting and loading.

Torque tests can reveal much about the true quality and geometry of the bearing. Investigations being conducted constantly are producing valuable contributions to the refinement of instrument bearings.



TORQUE TESTER

MOUNTING PRACTICE

An improper fit to the shaft or housing can cause malfunctioning and failure of a precision bearing. The factors vary so with each application that bearing manufacturers are reluctant to make definite recommendations unless adequate information is furnished. The user cannot be sure that he has selected proper fits unless he has considered the variables involved in the manufacture of both instruments and bearings.

For selective assembly "coded bearings" can be supplied. This involves sorting bores and outside diameters in .0001" increments. It produces four possible groups within the quantity ordered but quantities in any *one* group cannot be assured. Coding should be specified only when definite advantages justify the additional cost.

DESIGNERS HANDBOOK *FREE* TO ENGINEERS

If you work with miniature bearings, you'll find this new, 70 page authoritative publication a great help in solving problems in designing instruments or small electro - mechanical assemblies.

Free to engineers, draftsmen and purchasing agents.

Write New Hampshire Ball Bearings, Inc., Peterborough 1, N.H.

How **DENISON** hydraulic power works for **LOGEMANN BROTHERS CO.**

Putting more squeeze in presses

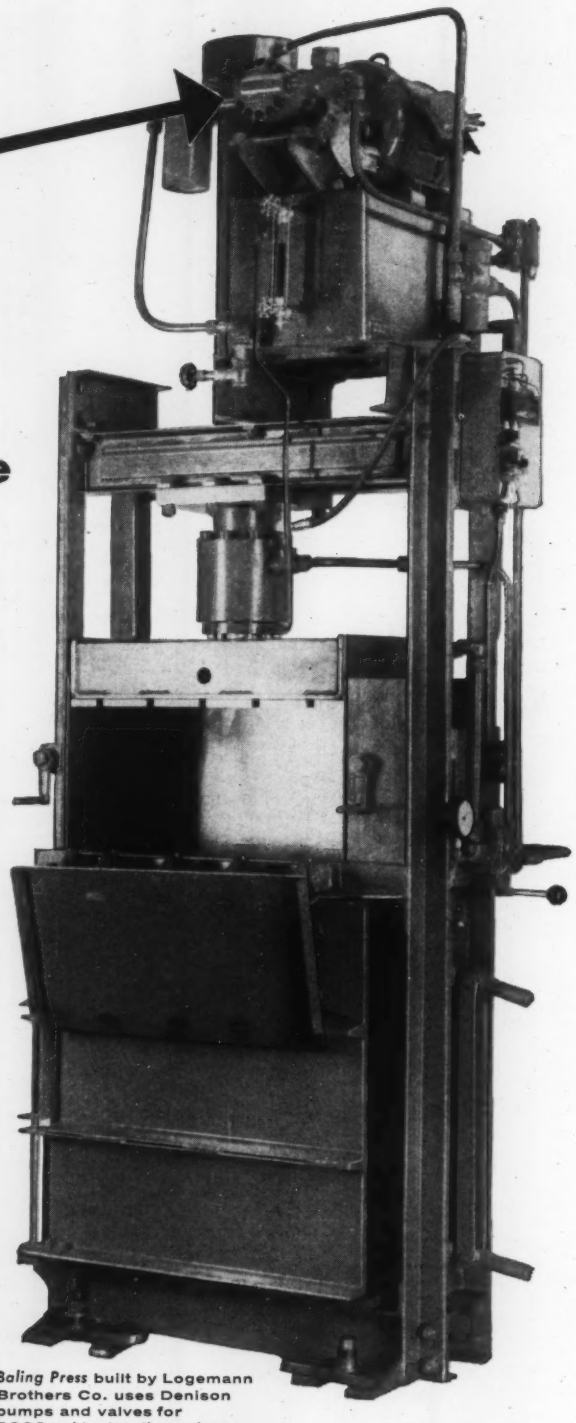
...another application for Denison hydraulic power

Here's how a leading manufacturer of baling presses assures peak performance for his product... combines it with dependability for long, continuous service.

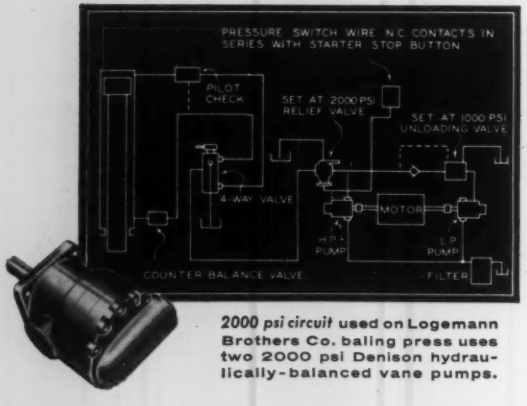
Power and speed of operation are achieved by the use of two 2000 psi Denison TMC balanced-vane hydraulic pumps. One Denison pump is set for 1000 psi for fast ram approach. The second pump is set for 2000 psi to provide necessary pressure for the power stroke.

By using identical 2000 psi pumps, maintenance is simplified and pump life greatly increased.

Endless design problems can be solved by using Denison hydraulic equipment on systems up to 5000 psi. Your Denison representative (who is an experienced hydraulic specialist) will gladly show you how. Write us. Denison Engineering Division, American Brake Shoe Co., 1240 Dublin Road, Columbus 16, Ohio.



Baling Press built by Logemann Brothers Co. uses Denison pumps and valves for 2000 psi hydraulic system.



2000 psi circuit used on Logemann Brothers Co. baling press uses two 2000 psi Denison hydraulically-balanced vane pumps.

Denison and Denison HydrOILics are registered trademarks of Denison Eng. Div., ABSCO

HYDRAULIC PRESSES • PUMPS • MOTORS • CONTROLS

DENISON HydrOILics

Proof why it pays to design *Carpenter* Welded Stainless Tubing into tough spots with "skin-tight" limits

Unusually close dimensional tolerances were required by the AEC on nearly 500 ft. of Carpenter Stainless Tubing now being used in the development of nuclear power reactors. The tubing of two different diameters is installed as shown by the above illustration through a 32½ ft. thick concrete wall. Temperature inside the tubing during operation ranges between 1600°F and 2000°F.

The outside tubing was produced within these close limits: 4.390" O.D. (+.000/−.025) ×4.100" I.D. (+.040/−.000); the inside tubing tolerances were: 3.830" O.D. (+.000/−.030) × 3.685" I.D. (+.040/−.000).

Let us demonstrate for you this same ability to produce uniform high quality corrosion and heat-resistant tubing to the tightest specifications. Call in your nearby Carpenter Distributor or Representative for a discussion of your needs.

MEMBER

The Carpenter Steel Company
Alloy Tube Division, Union, N. J.

Export Dept.: The Carpenter Steel Co., Port Washington, N. Y.—"CARSTEELCO"

Carpenter

Stainless Tubing & Pipe

Circle 551 on page 19

again available in reprint • • • •

"MECHANISMS FOR INTERMITTENT MOTION"

by Otto Lichtwitz

A SYSTEMATIC TREATMENT OF THE PROBLEMS INVOLVED FOR IMPARTING INTERMITTENT MOTION THROUGH EXTERNAL AND INTERNAL GENEVA AND STAR WHEELS, AND INTERMITTENT MECHANISMS FOR INTERSECTING AND CROSSING SHAFTS

In the December 1951, and January, February and March 1952 Issues, MACHINE DESIGN published what has proved to be an enormously successful series of articles on "Mechanisms for Intermittent Motion". Mr. Lichtwitz' approach to the subject of intermittent motion is systematic and extremely well organized. The tables provided to reduce time and effort in making detailed calculations are themselves invaluable.

We have re-reprinted a supply of booklets of this series because requests for copies have been constant ever since it was first offered . . . our initial supply ran out many months ago.

A worthy addition to your "working library" . . . use the handy form below and order your copies today! (Remittance enclosed with your order will speed the delivery of your copies.)

Order your copies today

(Add 3% to orders for delivery in Ohio to cover state sales tax)

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READER SERVICE
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Cleveland 13, Ohio

Send me_____ copies of "MECHANISMS FOR INTERMITTENT MOTION" at $1.00 per copy

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☐ Please bill me

Fastener Facts

by Henry Peterson, Chief Engineer — Judson L. Thomson Mfg. Co.

DESIGN PRODUCTION & PURCHASING DATA

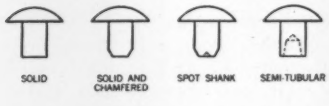
PRECIOUS METAL CONTACT RIVETS

Objective: Greater Reliability

When contact specifications call for higher-than-usual electrical or thermal conductivity or resistance to corrosion, precious metals take over from copper and brass. Many manufacturers of aircraft, automotive and electronic equipment have upgraded their electrical contacts with precious metals where the need for greater reliability has outweighed cost factors.

Wide Choice of Metals

To meet demand for contacts that perform efficiently under critical conditions, Thomson manufactures contact rivets in a wide variety of precious metals. They include: fine, coin, and sterling silver; all combinations of silver and copper; combinations of silver cadmium and nickel; pure palladium; palladium silver combinations; gold platinum and irridium combinations; and pure tin. This choice of contact materials allows designers to match electrical, physical and chemical properties to specifications for trouble-free operation under varying operational and environmental conditions.



Four Rivet Types

Thomson cold heads contact rivets for four application methods.

Solid Rivets are specified when contacts are to be hand set . . . a method used only when quantity or space limitations rule out the use of automatic setting machines.

Solid and Chamfered Rivets, used as duplicate head contacts . . . are clinched by high-speed automatic setting machines.

Spot Shank Rivets increase speed of automatic setting because their indented shanks allow the pilot pin in the anvil to pick them up faster and line them up more accurately.

Semi-Tubular Rivets, with their greater length and deeper holes, increase the speed and reliability of machine handling without increasing their weight or cost.

Cost Considerations

When specifications call for the high conductivity and corrosion resistance of precious metal contacts, but budgetary limitations indicate a lower price, we often suggest a compromise. Thomson Rivets, cold-headed from copper and brass and capped with silver, improve contact performance at a fraction of the cost of all-silver rivets.

However, the use of precious metal rivets doesn't always mean greatly increased costs. Manufacturers of light-bulb and fuse sockets have found that Thomson Pure Tin Rivets outperform lead solder contacts at a little or no price differential.

Design Factors

Head Shapes of Thomson contact rivets are designed to suit customers requirements. Most common shapes are oval, flat countersunk, ideal and button. As a rule, head diameter is between 1.75 and 2.75 times the shank diameter and head thickness between 0.3 and 0.6 times shank diameter.

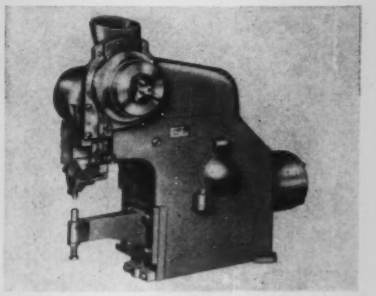
Shank Diameter of Thomson contact rivets range from .036 to .187, depending on wire sizes available in various precious metals.

Shank Lengths run from .6 to 6 times shank diameter. In semi-tubular rivets, length is generally determined by adding 55% of the shank diameter to the thickness of the materials to be fastened.

Hole Depths of Thomson Semi-Tubular rivets seldom exceed shank diameter. However, exact depth is determined by the clinch requirements in each case.

Tolerances of Thomson Precious Metal Rivets approach these of screw machine parts. Our precision machines hold tolerances to plus or minus 0.001" in high-speed production.

Clearances for rivets and rivet-setting machine driving heads and clinching tools should be considered early in the design stage. Hole sizes for rivets should be 1.07 times shank diameter. Ample room should be allowed for inserting rivets into the work and for driving and clinching mechanisms. Early consultation with Thomson engineers will help you design around the rivets and machines to be used.



BENCH-TYPE MOTOR-OPERATED MACHINE

Thomson High-Speed Machines

Users of precious metal contacts specify Thomson as much for the assembly speed of our machines as for the precision manufacturer of our rivets. Thomson has developed more than 250 styles of machines which can do thousands of fastening jobs . . . with or without adaptations. Automatic hopper feed, multiple rivet-setting heads, special work handling and loading fixtures are optional features that accelerate riveting operations. Thomson selects and custom-tools the proper machines and tests them on actual samples before shipment. You buy or lease them as you please.

Design and Engineering Service

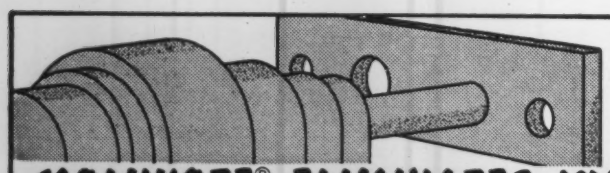
Thomson analyzes your company's contact or fastening problems and makes specific rivet and machine recommendations . . . at your request. When called in early, we can specify rivets and machines for minimum cost and maximum assembly speed. For work in progress, submit sketches, prints or samples for recommendations and quotations.

Free "Fastener Fact File"

Be one of the first to profit from our new manual in all phases of riveting. It covers types, applications, materials, finishes and other factors that simplify selection of the right design rivet and machine for lowest fastening costs. Request your copy today. Write Judson L. Thomson Mfg. Co., Dept. B, Waltham 54, Mass.

JUDSON L. THOMSON MFG. CO., WALTHAM 54, MASS.

Circle 552 on page 19



MOLYKOTE® ELIMINATES JUMPY 'STICK-SLIP' ON HEAVY GRINDER . . . AN IMPOSSIBLE JOB WITH OILS AND GREASES

Here's the way this report came to us:

"On a heavy cylindrical grinder, the grinding head which weighed 8,000 pounds had to be moved hydraulically at feed rates of .00025" per second. It turned out to be an impossible job with oils and greases. Finally, we cleaned the ways with benzine and rubbed in MOLYKOTE, Type Z powder. It sure was a relief to see the grinding head move without the previous jumpy, stick-slip behavior."

Impressive story? Yes, it is . . . but there are thousands like it from industrial concerns the world over. In their own words they tell us how design problems on low speed mechanisms at extreme pressure are solved by MOLYKOTE Lubricants.

More interesting reports from satisfied users of MOLYKOTE LUBRICANTS . . .

- . . . prolonged life of bronze Oilite connecting rod bushings 5 times on pneumatic sander. (Field Report 24-47)
- . . . dropped the temperature of rubber rolling mill bearings from 160°F to 95°F.
- . . . reduced friction 30% on rubber "O" rings, packings and seals.
- . . . multipled number of operating cycles in valve test 5 times.
- . . . reduced by 50% the power needed to move supports on ways and guides. (Field Report 24-31)
- . . . reduced load 25% in coining operation of plastics manufacturer. (Field Report 18)

The ALPHA MOLYKOTE Corporation

Main Factories: 65 Harvard Avenue, Stamford, Conn.
71 Arnulfstrasse, Munich 19, Germany

Circle 553 on page 19

IF YOU SIT HIGH, YOU'LL "SIT HANDSOME" IN A Cramer HI-MODEL CHAIR

COMPLETELY ADJUSTABLE ...fits YOUR build just right

• Scientifically planned in each detail, the Cramer Hi-Model has thick shaped-foam cushions and independently-adjustable seat, back and footring to support you comfortably and aid you in your work. Removable covers available in a wide choice of colors and fabrics.

OVER 100,000 CRAMER HI-MODEL CHAIRS NOW IN USE ALL AROUND THE WORLD!

LIKE MORE INFORMATION?

Cramer Hi-Model 4D-22T, pictured, with forward-tilt seat; others available, all low-gravity balanced for use ON CASTERS if desired.

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Please send complete facts on Cramer Hi-Model chairs for working architects and engineers.

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Young 3-1-2 COOLING SYSTEM TREATMENT

Rust and Corrosion Inhibitor

Young 3-1-2 is a complete protective treatment for diesel and automotive type cooling systems. It prevents rust, controls scale, and protects aluminum, copper, ferrous metals, etc., from corrosion; and non-metals from deterioration.

Young 3-1-2 is furnished in pellet form, and since it is a *non-chromate* type treatment, it is non-irritating to the skin. No weighing or measuring is required: *3* pellets to *1* gallon of coolant, *2* times a year (under normal operating conditions) are recommended.

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Creative HEAT TRANSFER ENGINEERS
Executive Office: Racine, Wisconsin, Plants at Racine, Wisconsin, Mattoon, Illinois

Circle 554 on page 19

Circle 555 on page 19

SAVE Time, Expense and Effort with ANCHOR FLANCO® 4-Bolt, Split-Flange, "O" Ring CLAMP

—with the TILT-PROOF and BLOW-OFF PROOF DESIGN

It provides an easily made, leak-proof "O" Ring Head Connection, with no threads to wear out or tapered seats to groove — no wedging of pump or valve bodies by tapered pipe threads. Gaskets and sealing compounds are eliminated. The higher the pressure, the tighter the "O" Ring seals.

Anchor Flanco Split-Flange Couplings are used to connect hose to valve or pump bodies, hose to hose and hose to pipe. Designed for high or low pressure, available in ½" to 3" I.D. Hose.

Available 4 Ways

- Pressed-On Couplings — utilizing Anchor's time-proved swaging methods.
- Clamp-Type Couplings — ideal for emergency repair.
- Weld-Type Couplings — for connecting pipe or tubing.
- Stem Angles — 0° to 90°, with Flanco Swivel Split-Flange's 360° swiveling, they provide universal coupling.

Write for Catalog No. 401

ANCHOR COUPLING CO. INC.

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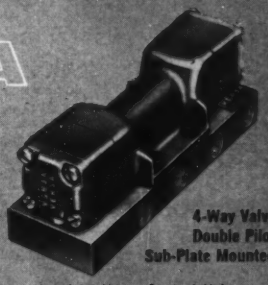
Circle 556 on page 19

FOR SUB-PLATE MOUNTING

VERSA **Manifold Mount VALVES**



4-Way Valve Double Pilot Sub-Plate Mounted

For any type of operation...there's a Versa Control Valve available for manifold mounting. These efficient, compact Control Valves are ideal for incorporation as original equipment. They can be installed directly on equipment or mounted on standard Manifold Plates (or Sub-Plates).

Versa Manifold Mount Valves are available with any type of actuating device, in sizes from 1/8" to 1" NPT, in 2-, 3-, 4-, and 5-Way Types, and for pressures from partial vacuum to 500 PSIG.

Over 110,000 Variations... Available for Immediate Delivery!

VERSA

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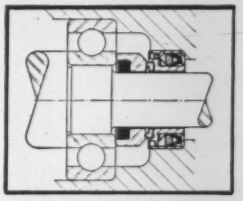
247 SCHOLES STREET, BROOKLYN 6, N.Y.

Circle 557 on page 19

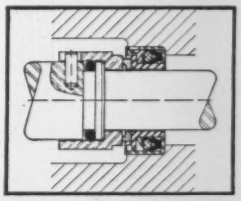
For Proper Sealing . . . DEPEND ON THE SEALOL ENGINEER!

Shaft Seals Function Best When Properly Engineered To The Job

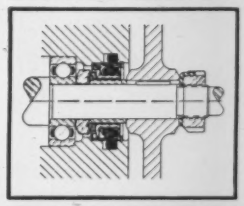
The typical examples shown below indicate the variety of methods possible in the application of mating rings for Sealol seals.



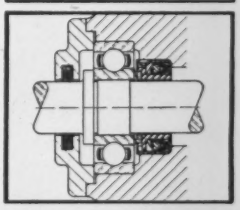
This mating ring is a push fit on the shaft. Interference is at the rubber packing, not metal to metal. The packing both drives and seals. Ring is squared by bearing or shoulder. Not recommended for high pressure applications as ring is hydraulically overbalanced away from shoulder. Seal is press fit in housing.



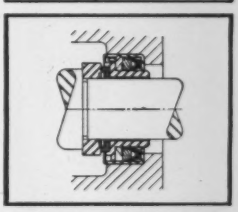
This mating ring is a slip fit on the shaft and positioned against shoulder. Ring is sealed to the shaft by the "O" ring in a groove and is driven by the pin. This ring is hydraulically overbalanced *toward* the shoulder and is, therefore, suitable for high pressure applications.



This mating ring is a close tolerance slip fit on shaft, held against bearing or shoulder by mechanical make-up. This make-up provides drive and leak-tightness to shaft. In this picture the seal is a slip fit in housing for easy assembly and removal and sealed to housing by an "O" ring.



This mating ring is actually the inner ring of the bearing. The inner ring must be mounted leak-tight to the shaft and positively driven (press fit). The ring face must be lapped flat and smooth. This arrangement saves space but its use is limited by the amount of frictional heat input the bearing will accept and by the limitation of choice of material.



This mating ring is a press or shrink fit on the shaft, positioned by shaft shoulder. This method requires close tolerance dimensional control of shaft and ring hole diameters. Since press or shrink fit can distort previously prepared face, this type ring is recommended only when other solutions are not practical.

These examples illustrate the necessity for decisions. The Sealol Engineer can make these decisions for you based on intimate knowledge and experience. Consult him for solutions of your shaft sealing problems.

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SEALOL

THE BALANCED PRESSURE SEAL

Circle 558 on page 19

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for fuel, air, hydraulic and oil lines

ALCOA® UTILITUBE, the coiled aluminum tube, actually costs as much as *40% less* per foot than copper tube. That saving becomes more important when you realize that it comes with no sacrifice in performance and quality. You can count on ALCOA UTILITUBE for dependable service in fuel, air, gas and hydraulic lines. Here's why:

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LIGHT WEIGHT—⅓ weight of copper; long lengths easier to handle.

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FITTINGS—readily available in aluminum from several manufacturers.

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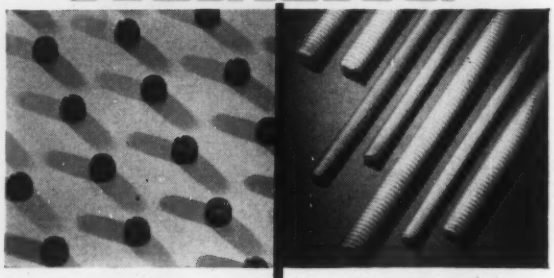

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Nylon Threaded Rod

Excellent dielectric properties—non-corrosive

Tough, flexible Rod makes U-bolts, dielectric spacers, studs, etc. Use Cap Nuts with Rod or screws or as knobs. Write for literature and prices.

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Circle 560 on page 19

Design Guide to

"Adjustable-Speed Drives"

- **ELECTRICAL**
- **MECHANICAL**
- **HYDRAULIC**

Here, in one book—148 pages, with 24 tables, 119 charts and 171 illustrations—is what the designer should know about adjustable speed.

$2.00 per copy

MACHINE DESIGN READER SERVICE
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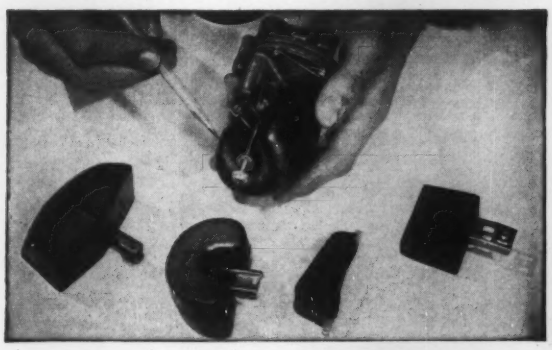

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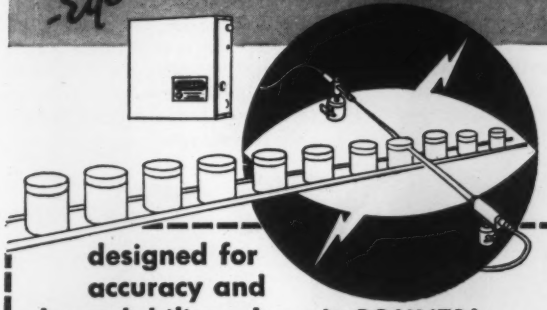
Parker
Hydraulic and fluid system components

Circle 561 on page 19

Robot-Eye PHOTO ELECTRIC CONTROLS



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ROBOT-EYE Photo Electric Controls incorporate many of the newest and most advanced features of electronic design and component miniaturization, for greater efficiency and versatility of application.

THESE ROBOT-EYE FEATURES MEAN A HIGHER STANDARD OF OPERATION:

- Light and cell unit—swivel mounted for easy installation.
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- Unit will follow counting operations up to 600 per minute.
- Robot-Eye unit works from either direct beam; reflection from object or mirror reflection.

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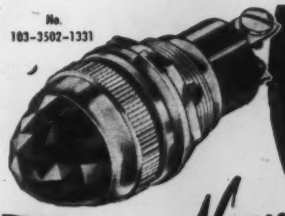
STANDARD INSTRUMENT

VISIT BOOTH 855 AT I.S.A. SHOW!

Circle 562 on page 19



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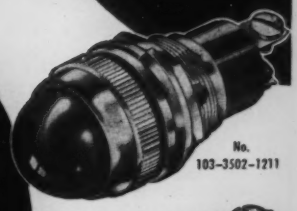

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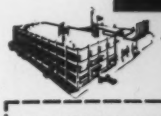

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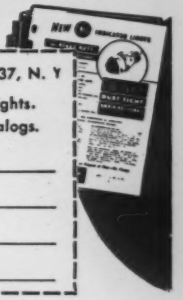

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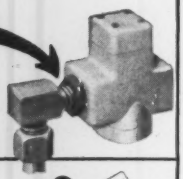
Circle 563 on page 19

TRU-O-SEAL
TEFLON SEAL

STOPS PIPE THREAD LEAKS

PAT. PENDING



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TRU-O-SEAL Fittings are guaranteed to seal pipe thread connections permanently against all oils, practically all known chemicals and gases; to seal under high pressures or vacuum; to withstand —280° to plus 500° F.; to eliminate "overtightening" damage and pipe dope. Available in ⅛" to 2½" pipe thread sizes.

$10.00 Trial Offer No. 1: eight ⅛", ten ¼", eight ⅜", ten ½" pipe thread TRU-O-SEAL Fittings.

$10.00 Trial Offer No. 2: eight ½", ten ¾", four 1" pipe thread TRU-O-SEAL Fittings. **Send order to**

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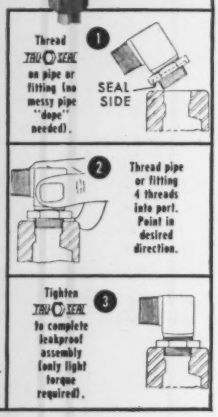
"Miller Fluid Power" is also a Div. of Flick-Reedy Corp.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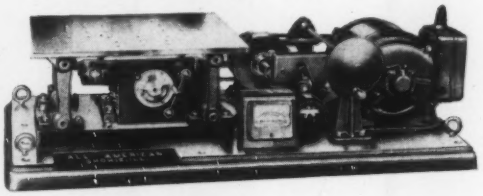
Thread TRU-O-SEAL on pipe or fitting (no messy pipe "dope" needed).
SEAL SIDE
2
Thread pipe or fitting 4 threads into port. Point in desired direction.
3
Tighten TRU-O-SEAL to complete leakproof assembly (only light torque required).

Circle 564 on page 19

Parts, Assemblies, Up to 150 lbs. Given Vibration Fatigue Test on the ALL AMERICAN Model 150 HLA-D



This machine, subjects parts or assemblies, up to 150 lbs. in weight, to a comprehensive vibration fatigue test. It has a 50% overload safety factor. Vibration in simple harmonic motion is produced horizontally. Displacement (double amplitude) is adjustable from 0" to .125". Automatic Range Selector controls acceleration and deceleration. From 10 cycles per second frequency may be increased uniformly to 60 c.p.s. and then decreased to 10 c.p.s. Any desired range within the total may be selected. Selector can be switched off and frequency held at any c.p.s.

Recommended for testing aircraft, electronic, electrical, mechanical or optical parts or components. One of 7 models. Send for Catalog F, containing helpful data nomograph chart and listing typical users. Write to

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Makers of All American Precision Die Filing Machines

Circle 565 on page 19

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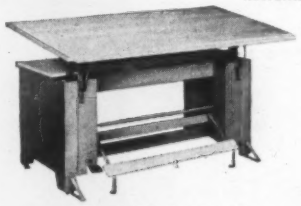

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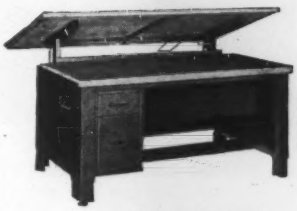

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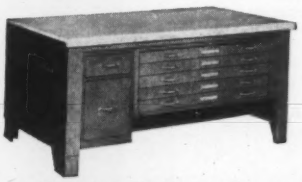

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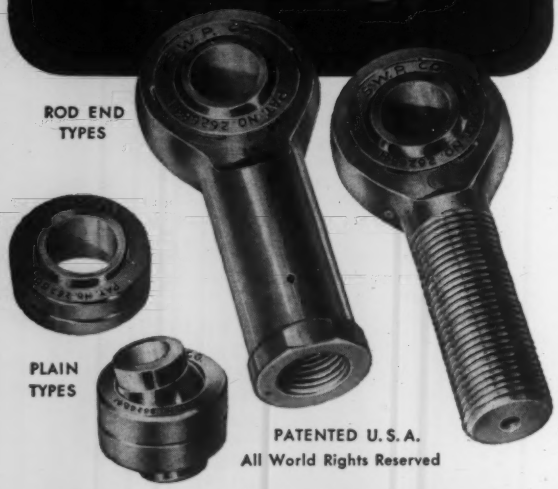

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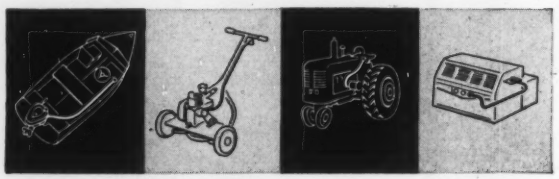

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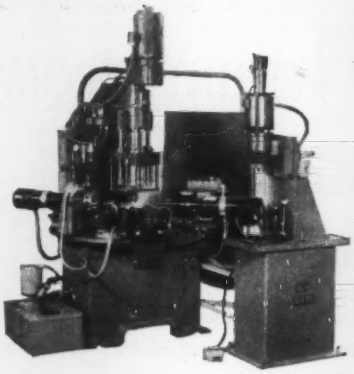

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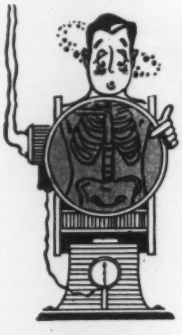

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Fig. 811
Flow Indicator

Fig. 816
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Circle 572 on page 19

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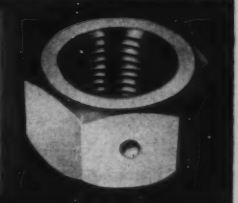

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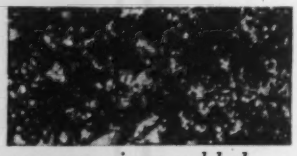

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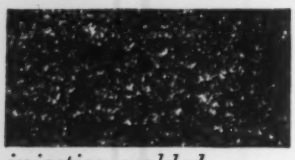

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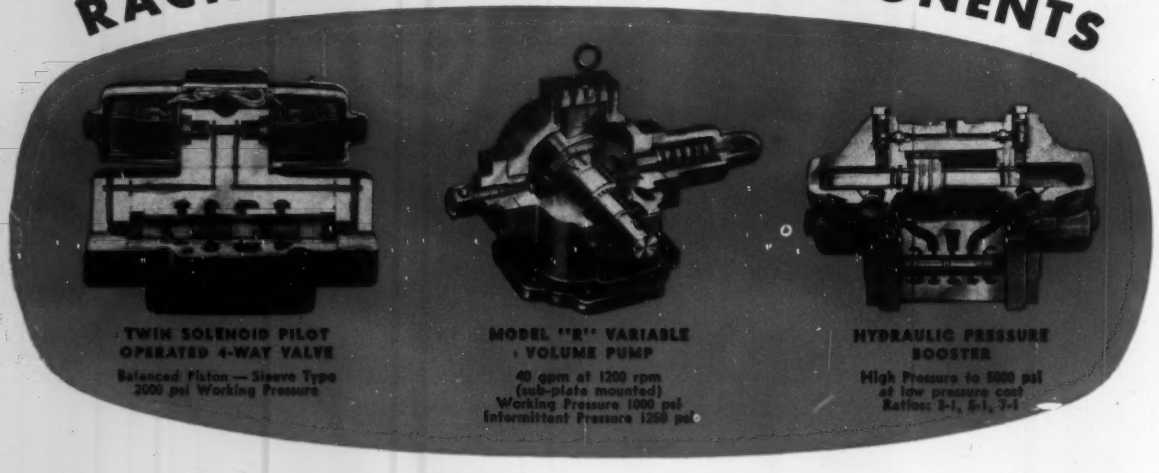
RACINE HYDRAULIC COMPONENTS


TWIN SOLENOID PILOT OPERATED 4-WAY VALVE
Balanced Piston — Sleeve Type
2000 psi Working Pressure
MODEL "B" VARIABLE VOLUME PUMP
40 gpm at 1200 rpm
(sub-plate mounted)
Working Pressure 1000 psi
Intermittant Pressure 1250 psi
HYDRAULIC PRESSURE BOOSTER
High Pressure to 5000 psi
at low pressure cost
Ratios: 3-1, 5-1, 7-1

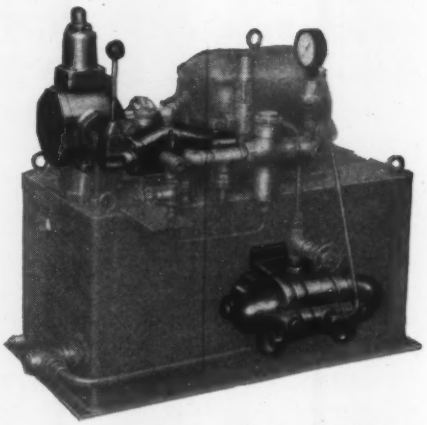
Assure installation and operation economies

IMPORTANT TO YOU!

INSTALLATION ECONOMIES — Racine designed and built hydraulic "Power Units" are compact — yet all components are easily accessible for quick servicing. Hook-up to your equipment is fast and simple.

OPERATION ECONOMIES — With Racine Variable Volume Pumps and Boosters, you get high-pressure results at low-pressure cost. *You put all of the oil to work.*

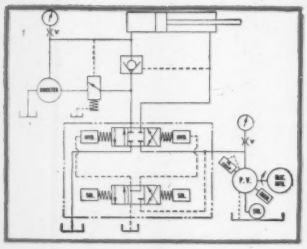
EQUIPMENT ECONOMIES — Racine's unique hydraulic design requires a minimum of components, thus extreme circuit simplification.



TYPICAL RACINE "POWER UNIT" DESIGNED AND BUILT TO YOUR SPECIFIC NEEDS

FREE ENGINEERING SERVICE

Augment your busy, short-handed engineering team by taking advantage of our specialized hydraulic engineering service at *no cost to you.* Write us about your problem — no obligation.



RACINE HYDRAULICS & MACHINERY, INC.
2073 Albert Street
RACINE, WISCONSIN, U. S. A.

Circle 576 on page 19

Spurgeon Automation Unit on the test floor of the Spurgeon Company at Van Dyke, Mich. Note the vital points where Clevelands are installed—a small unit (20AT) driving the feed mechanism and two 70ND units, one at each end of the elevator lift.

Spurgeon automation unit employs three CLEVELANDS

IN a Detroit automotive plant, three Spurgeon units automatically elevate, transfer and feed steel bars into bar cut-off machines. Top production is gained and hours of man power and money are saved by automation.

Three Cleveland Worm Gear Speed Reducers are employed on each Spurgeon unit: Two vertical reducers on the mechanical drive that operates the elevator; a third Cleveland on the "V" Roll Conveyor pushes the rods into the bar cut-off machine.

Automation and Cleveland Worm Gear Speed Reducers go hand-in-hand. Precision matching of case-hardened steel worms to nickel-bronze gears insures 100% dependability. And, the compact, right-angle Cleveland design saves space and makes installation easy.

Find out what Cleveland can do for your operations before you buy. Catalog 400 gives the story. The Cleveland Worm and Gear Co., 3287 E. 80th St., Cleveland 4, O.

Affiliate: The Farval Corporation, Centralized Systems of Lubrication. In Canada: Peacock Brothers Limited.

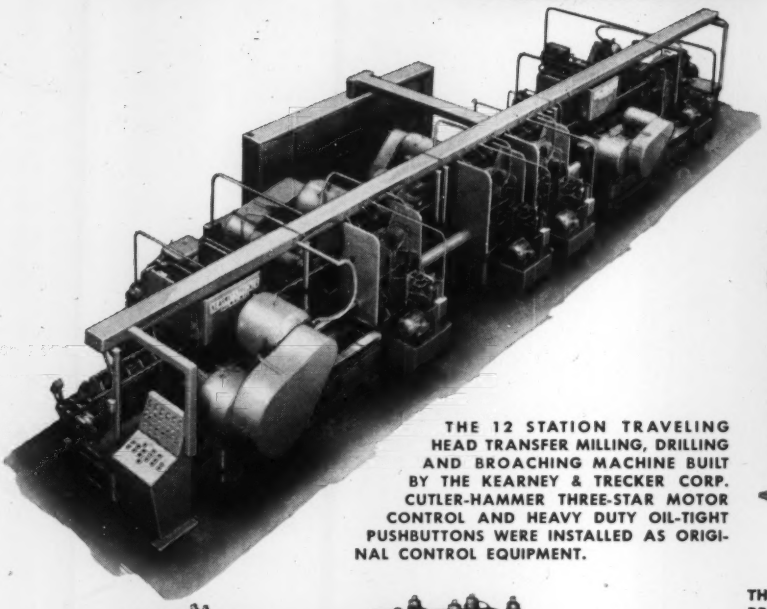
CLEVELAND
Worm Gear
Speed Reducers

Circle 402 on page 19

Choice of the Leaders

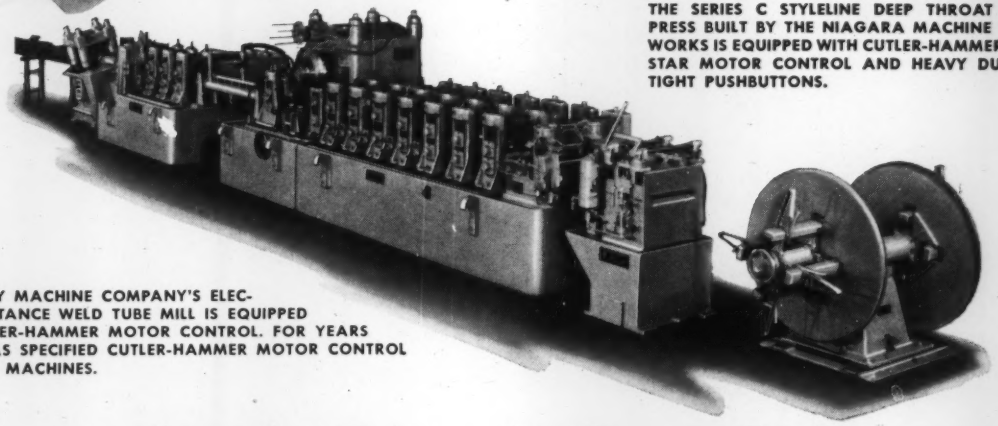
CUTLER-HAMMER
MOTOR CONTROL
C-H

The Mark of Better Machines



THE 12 STATION TRAVELING HEAD TRANSFER MILLING, DRILLING AND BROACHING MACHINE BUILT BY THE KEARNEY & TRECKER CORP. CUTLER-HAMMER THREE-STAR MOTOR CONTROL AND HEAVY DUTY OIL-TIGHT PUSHBUTTONS WERE INSTALLED AS ORIGINAL CONTROL EQUIPMENT.

THE SERIES C STYLELINE DEEP THROAT POWER PRESS BUILT BY THE NIAGARA MACHINE & TOOL WORKS IS EQUIPPED WITH CUTLER-HAMMER THREE-STAR MOTOR CONTROL AND HEAVY DUTY OIL-TIGHT PUSHBUTTONS.



THE McKAY MACHINE COMPANY'S ELECTRIC RESISTANCE WELD TUBE MILL IS EQUIPPED WITH CUTLER-HAMMER MOTOR CONTROL. FOR YEARS McKAY HAS SPECIFIED CUTLER-HAMMER MOTOR CONTROL FOR THEIR MACHINES.

Let the Stars be Your Guide

Whether or not a new machine can do a needed job is not difficult to determine. But the big question to be answered *before* purchase is always, "Will it do the job day after day for years without trouble and delays?"

Experienced buyers are not concerned by this question which time must answer. They know there are reliable guides to dependable machine performance and they base their judgment on these when making selections. One such guide which is widely used is Cutler-Hammer Three-Star Motor Control.

Cutler-Hammer Three-Star Motor Control does more than assure the buyer the electrical equipment is completely dependable. It shows the standard to which the machine was designed and built. It has long been the choice of the leaders and the mark of better machines. CUTLER-HAMMER, Inc., 1310 St. Paul Avenue, Milwaukee 1, Wisconsin. *Associate:* Canadian Cutler-Hammer, Ltd., Toronto.

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